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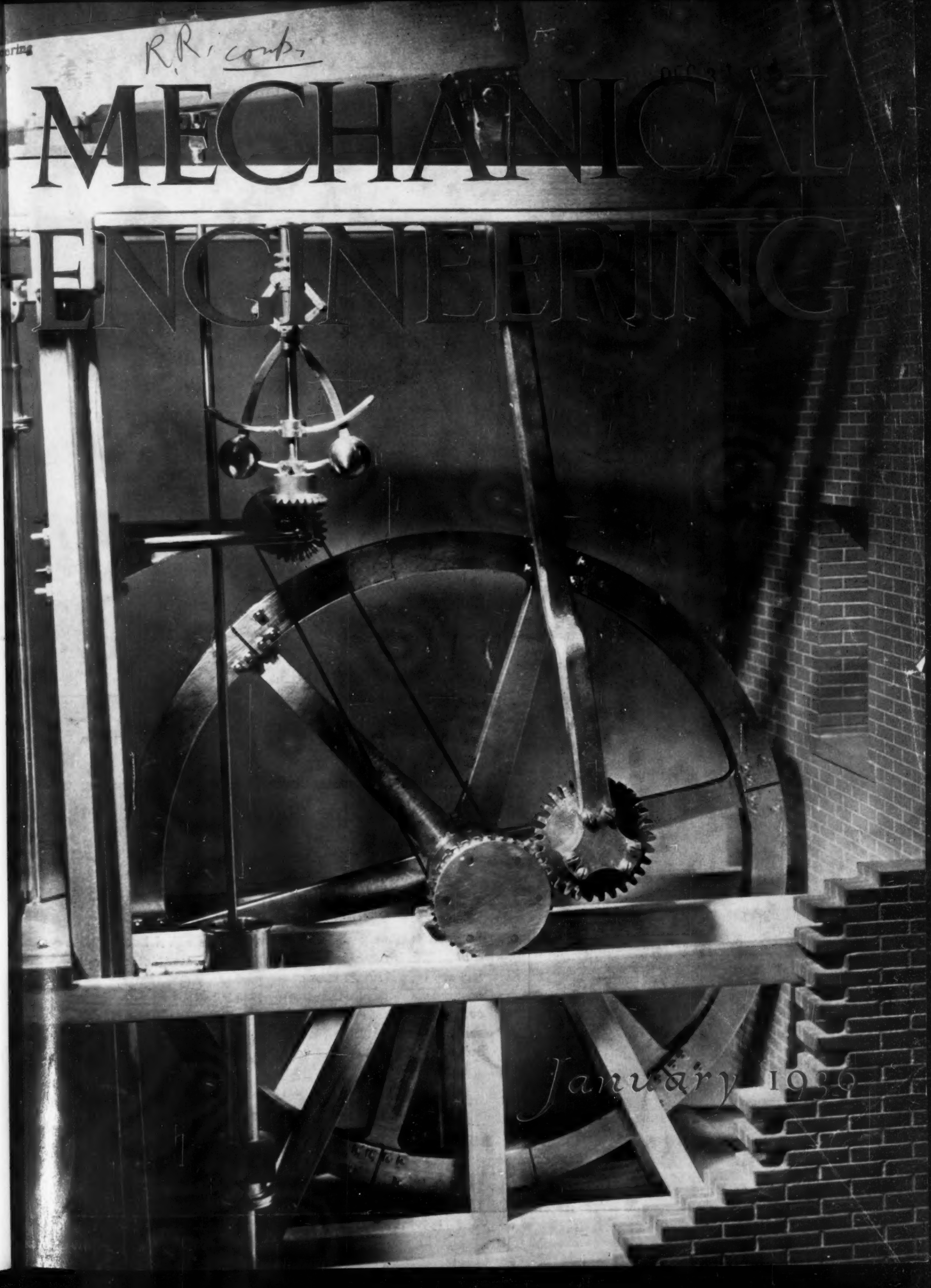

January 1936

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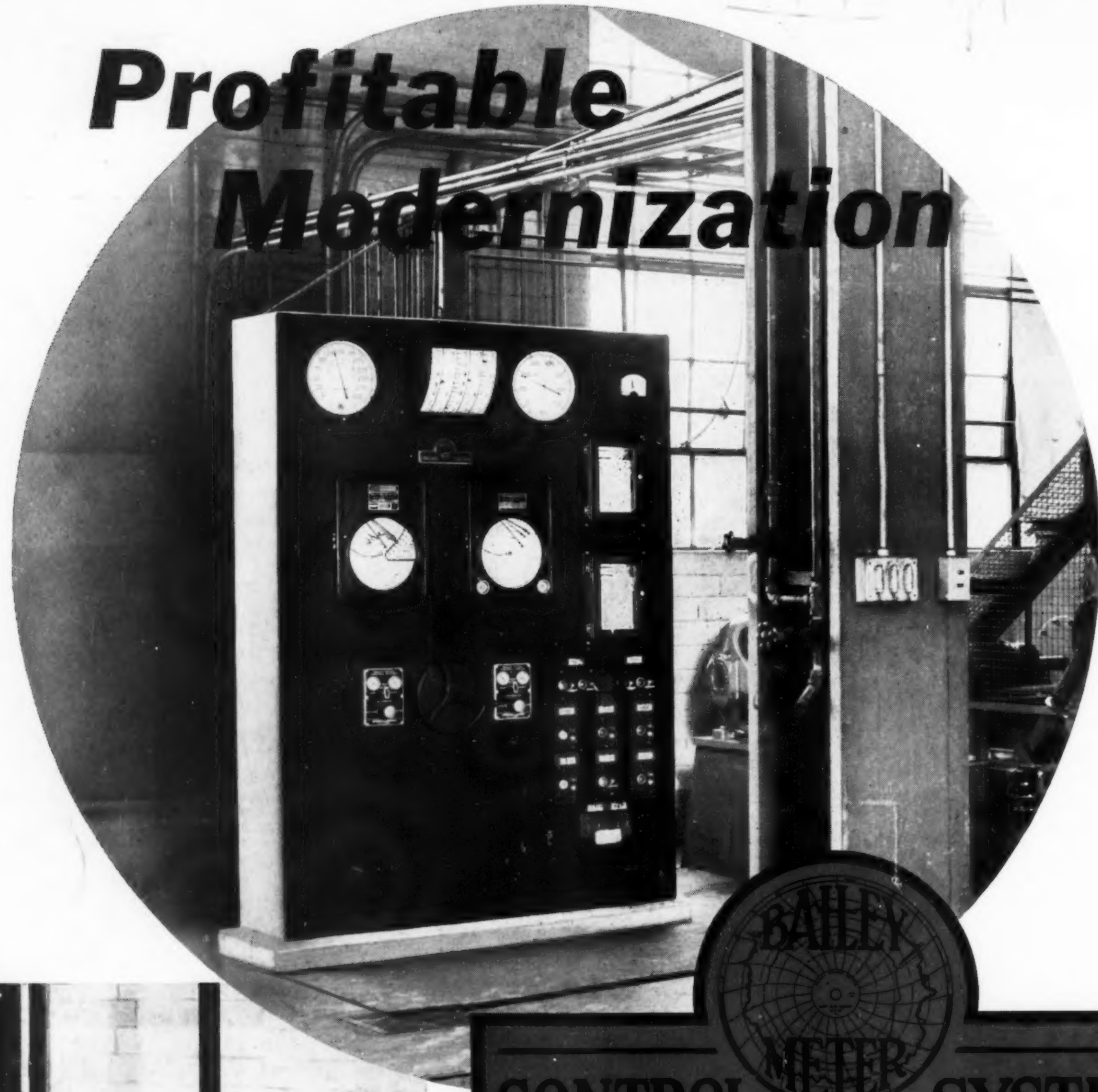

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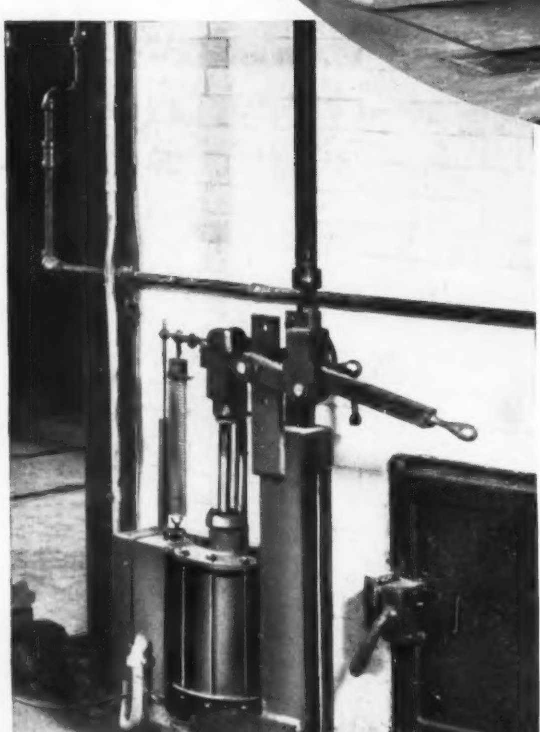

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MECHANICAL ENGINEERING

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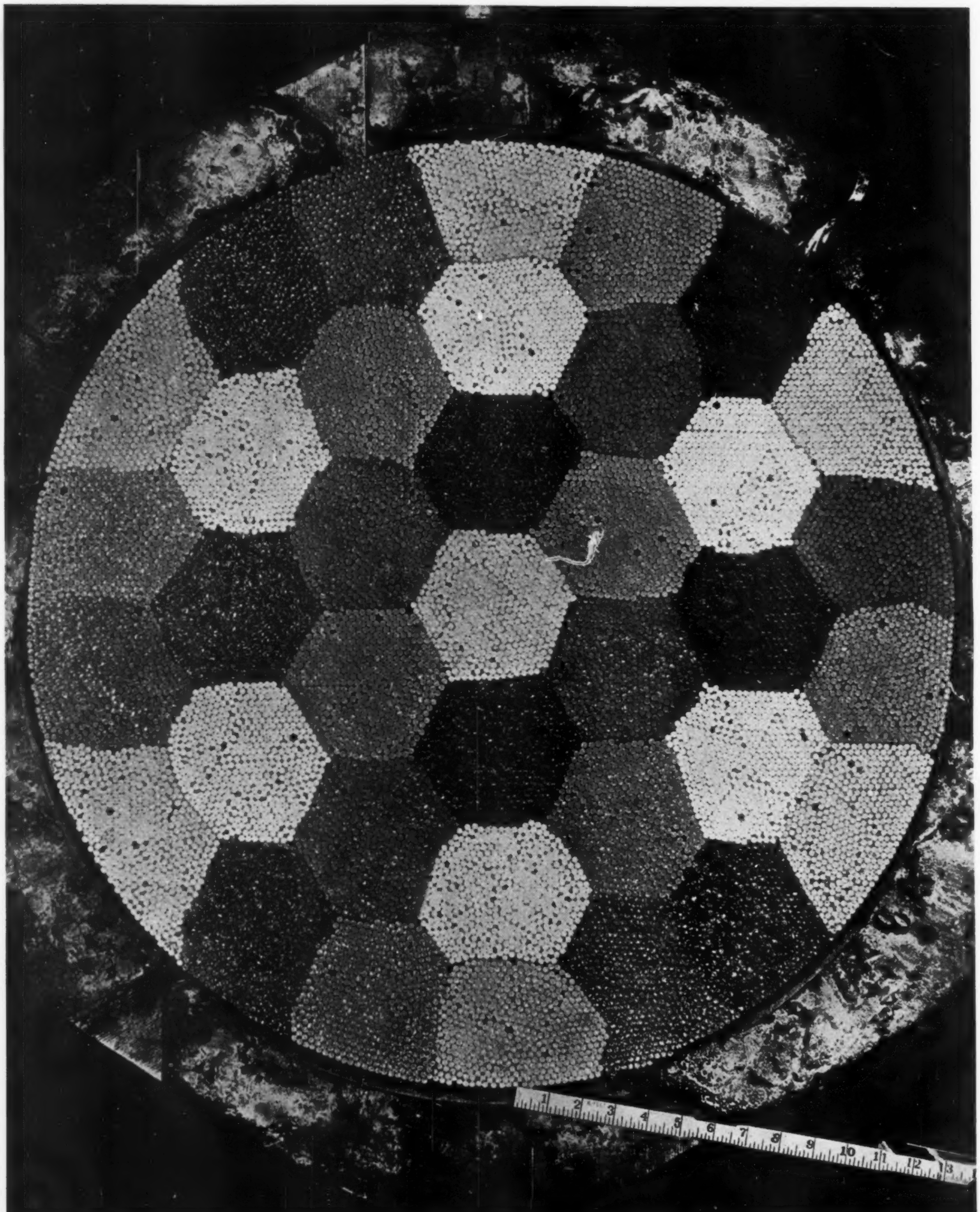

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Volume 58
No. 1

MECHANICAL ENGINEERING

January
1936

GEORGE A. STETSON, *Editor*

A Decade of Service

YEAR after year Erik Oberg has sat in the meeting of the A.S.M.E. Council and heard himself nominated its treasurer, with the amendment, gleefully offered by some wag, "at double his present salary." Year after year he has accepted this position of trust and responsibility with all of the ardors and endurances it entails; and has left the Council meeting to enjoy the remuneration of twice nothing in cold cash, but the intangible one of a feeling of satisfaction in the worthy performance of a necessary function and of the gratitude of his fellow officers and fellow members for that service. At the December meeting of Council, 1935, he forestalled the customary nomination by convincing his colleagues that no man should be expected to hold the office of treasurer forever and that he should be released from further obligation to serve. Regretfully, the Council heeded his plea, for willing workers with proper qualifications are not easily found.

Erik Oberg has served the Society in some of the most trying years of its history. Post-war readjustments that resulted in the depression of 1920–1921 had a serious effect on the finances of the A.S.M.E. It was at this time that Mr. Oberg was appointed to the Finance Committee, on which he served until 1925 when he became treasurer. Throughout these years, his sound judgment and good sense exerted a powerful steadying influence in maintaining a financial policy which brought the Society into the years of prosperity equipped to perform its normal services in a greater measure. The upward swing of post-war prosperity was well started toward dizzy heights during his first appointment in 1925. Society finances mounted and the treasurer's office was faced with the responsible task of investment. But a greater test came following the slump of 1929 when in the scramble of descending budgets, income always fell faster than expenses, and securities lacked markets and stable values.

Through this trying period those virtues of commonsense and stability that are built into the Scandinavian races lent wisdom and substance to Mr. Oberg's acts as treasurer and to his counsel as an officer of the Society and member of the Finance Committee. As is natural in times of economic disturbance, the wisdom and judgment of the Council and officers of the Society were sometimes questioned during this period by certain individuals, but against Mr. Oberg personally no criticism was ever raised. He can turn over his duties as treasurer to this successor, W. D. Ennis, with a knowledge that he stood by the Society in its days of deepest distress in a manner which does credit to his character and that he has earned the respect and gratitude of members, officers, and Council.

Two Hundred Years of Watt

IT IS always profitable to ponder the life of James Watt and the significance of his work and times. Today, two hundred years after his birth, a revaluation of the social and economic meaning of the epoch of which he was an outstanding figure is more than usually necessary. For the world today needs a clear perspective of what has been called the industrial revolution and of the particular relationship to it in which we find ourselves.

Watt's work was done in times no less disturbing than our own. Old orders were giving place to new. The spirit of change and revolution was abroad in the world. An agricultural and commercial society was facing the unfamiliar problems of industrialization. England was setting up the facilities that were to make her the workshop of the world. There was an active, an aggressive, interest in popular government, an expansion of markets and means of transportation, and a practical development of science and invention. Machinery was displacing human labor, and while it added enormously to the productivity of the world, it brought with it dislocations and fears that the world has not yet been able completely to understand. A spirit of inquiry in political economy was giving birth to the study of economics—Adam Smith was writing about the wealth of nations and of the division of labor; toward the end Ricardo and Malthus were presenting divergent theories of value, and the latter was expressing his fears that future inadequacy of food supply would place limitations on the growth of populations, a fear that the increased productivity resulting from the growing machine was to dispel before the fatal day arrived. They were stirring, if disturbing, times.

Against this background Watt did his work; of these revolutionary developments he was a part. But only a part, regardless of how important it was. For Watt's work was not done single-handed, nor was his vision always clear and foresighted. He affords an illuminating example of what the world has since more clearly recognized—the essential need for the cooperation and coordination of many factors of contemporary development.

In the first place the world learned anew what it has always known, that the man is a creature of his times and

environment. Without drowning coal mines headed for bankruptcy there would have been no market for Watt's pumping engine, and without the rapid development of textile machinery no great need for a rotative engine. The seed of Hero's aerophile fell on no such fertile ground.

Without Boulton, that great-hearted, far-sighted, indomitable, and astute business man, Watt's life and efforts would have ended in frustration and the bitterness of disappointment and failure. Great as was his genius it might easily have gone unsung to a nameless grave had not that inventiveness been implemented and made practicable by this business partner. So ended Trevithick because he had no Boulton.

But even courage, vision, and business acumen would have availed little had not Wilkinson provided the boring mill so that the enormous steam cylinders, necessary with Watt's low-pressure engine, could be bored with sufficient accuracy to prevent excessive leakage. The rise of the machine tool and of increasing precise and skillful machine work were essential factors in Watt's success.

And finally, of important contributory developments must be recalled the scientific work of such men as Black and Robison, upon whom Watt leaned heavily and with whom he worked. It was through the happy combination of all of these elements that Watt's work came to fruition and his contributions to the infant industrial epoch were made effective.

Time has not dimmed the glory of Watt's achievements, nor eliminated the necessity for active cooperation and coordination of these contributory elements. Instead, it intensifies them. Side by side with increases and developments in power have come those in the management of industrial organizations, in machinery and manufacturing technique, and in the enlarged possibilities for growth resulting from advances in applied science and research.

Falteringly, but with increasing rapidity, social, economic, and political conditions are changing as the western world attempts to adjust its life to the new conditions which industrialization forces upon it. Today we suffer acutely from these growing pains. Power becomes a national issue; the capitalistic system is brought into question; democracies are finding themselves unable to resist the impact of readjustments; unbalance in the national economy brings crises in finance, in agriculture, in the extractive and service industries, and in employment. The world experiences the disturbing effects of social and economic revolution, as it did in Watt's day.

It is not too much to hope that elements of modern society that were introduced in Watt's day will provide the essential means by which our own affairs will right themselves and carry us forward. More power and labor-saving machinery, improved techniques, lower costs and prices, more abundant utilization of the fruits of research and applied science, the coordination of production and distribution, and the perfection of all of these mechanisms in an intelligently and closely integrated whole will not bring back the past, lamented by some, but may, if we keep our heads, insure a happier future.

In the two hundred years since Watt's birth a former mode of life has been passing away and a new one has been gathering headway. Its immediate dislocations are our present distress, but not our doom, unless we will it so.

Roscoe R. Leonard

IT IS a sad duty to record the sudden death of Roscoe R. Leonard, since 1926 a member of the secretarial staff of The American Society of Mechanical Engineers and since 1929 representative of the Society at its Mid-West office in Chicago.

Mr. Leonard had come to New York for the annual meeting of the A.S.M.E. and when last seen by his associates on Saturday, December 7, was apparently in the best of health and spirits. Death, several hours later, resulted from a cerebral hemorrhage and was almost instantaneous.

Mr. Leonard became a member of the A.S.M.E. headquarters staff in 1926 and for several years served in the editorial department. He had previously been associate editor and assistant secretary of the American Society of Refrigerating Engineers. His advent to the A.S.M.E. staff was at a time when the Society's publications were undergoing drastic revision and enlargement as a result of the change from an annual volume of Transactions to a series of publications comprising the papers presented at the meetings of the professional divisions. To the extensive correspondence necessary to make clear the fact and purposes of this change to members who were confused by it, he devoted much time. Members of the Fuels Division will recall his services in connection with the widely attended national meetings of that division which marked the unusual technological developments in stoker and pulverized-fuel practice of the late twenties. He also edited a question and answer department under the auspices of the divisions that was a feature of MECHANICAL ENGINEERING for a few years.

When the A.S.M.E. Council voted, in 1929, to open a Mid-West office in Chicago, in order to bring the services of the Society's headquarters staff closer to members in that district, Mr. Leonard was assigned to the office. A native of Indiana and a former student at Purdue University, he brought to his duties in that post a sympathetic understanding of its problems. Among the members in Chicago and vicinity he made many warm friends. His visits to the local sections and student branches in the territory served by his office were of value to the Society and to the members in that district who felt that they had in him a personal representative. His two hundredweight of geniality won many friends, and his willingness to be of service will be sorely missed.

NEW PIONEERS *on a* NEW FRONTIER

By RALPH E. FLANDERS

PRESIDENT, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

THE greatest fact in American history has been the existence of the frontier.

For centuries the centers of industry, commerce, and settled agriculture lay in the East, expanding decade by decade in a westward progress that was uninterrupted and successful. The border line of that movement was held by the pioneers. Before them lay the unknown regions which the imagination pictured as teeming with wealth of forest, mine, and soil. Behind them came the settlers, who found and developed the underlying realities of the pioneer's dream.

This physical, geographical frontier for many generations served our nation in three important ways; it gave unlimited opportunity to youth, it furnished a seemingly boundless field for the profitable investment of capital, and it generated a favorable psychology throughout the whole structure of American society.

The opportunity for youth was a visible actuality at so recent a date as to be remembered by many in this gathering tonight. In the eastern farming regions the process was almost automatic. With the large families of a generation or two ago it was obviously impossible for all to gain a good living on the restricted home acres. The boys in due time moved outward, some to the cities (themselves growing with the growing commerce to and from the frontier) and others directly to the virgin soil and forest of the newly opened lands, where they could find the opportunity and the room to make new lives for themselves on a more ample scale.

But so widespreading and rich was the western domain that the expanding population of the eastern seaboard was insufficient to occupy and develop its resources. Their numbers were swelled by the millions from the crowded countries of Europe who descried the opportunities from afar, swarmed into the transatlantic shipping, and crowded the immigrant trains into our virgin territory. The numbers of these immigrants were numbered by the millions and tens of millions. Our own population growth did not suffice. There was room for all.

Money was needed as well as men. There were farms to be equipped, mines to be opened, roads and railroads to be built, cities to be erected. For generations the savings of the settled East poured across the Alleghenies, across the Mississippi, across the Continental Divide, and found profitable investment in these new and rich territories. Fortunes were lost, but more fortunes were made. There was never a word of "overproduction" or "overinvestment." The thought was so ridiculous that the words were unneeded and uninvented.

As with men, so with money. The savings of the East were inadequate to the needs and opportunities of the West. In consequence, millions of dollars came pouring out of the coffers of Europe to finance the settlement of western America, and the expansion of eastern commerce and industry which western development demanded. The millions grew into billions before the demand was satisfied and the stream slacked its flow.

All of this produced a national psychology of a fortunate sort. We were convinced that the future held more for us than the present and the past. We were willing to risk time and money in productive enterprise. The future, we were sure, would not betray us—nor did it. Even as our physical surrounding made our psychology, so our psychology made our future. The process was natural, healthful, fortunate beyond all accounting.

But—the frontier is gone!

No doubt we will continue, now and then, to find new oil fields. New areas of fertile soil will be irrigated and added to our inheritance of arable land. New mineral deposits will be found and exploited. All this will go on continuously for many years, yet the total effect will be small. It will not constitute the outstanding, controlling fact of our nation's history, as it did for nearly three hundred years. Sometime in the period since the turn of the century—not on any given day or in any given year—the physical frontier in the grand sense disappeared and disappeared forever.

This was the greatest event of our times. If we are looking for some effective cause for the evils which have been afflicting us, why look further? We build up our false or inadequate theories of "overproduction" when we have never had a decent general standard of living in this country; of "technological unemployment" when on technology alone can we found our hopes for the higher standards of the future; of "overinvestment" when an adequate provision of goods and services to the mass of our fellow citizens requires larger and more efficient productive facilities than we have ever dreamed of. All of these explanations and many more are shallow and inadequate.

Eighth Henry Robinson Towne Lecture on Engineering and Economics, delivered as the 1935 Presidential Address at the Annual Meeting, New York, N. Y., December 2–6, 1935, of The American Society of Mechanical Engineers.

The outstanding historical event of our generation is the disappearance of the frontier, and the consequent disappearance of the old, trusted, and tried opportunities for youthful opportunity and the profitable investment of capital; and with these gone there is beginning to go that favorable, constructive type of national psychology which has energized our progress hitherto.

What shall we do in the face of an emergency so fundamental?

Two courses are open to us. We can readjust our social, political, and industrial institutions to a future of limited opportunities for men and for money, with a national outlook keyed down to safety as our objective, instead of the old purposeful advance toward a better future. The alternative is that we find an equivalent for the lost frontier—an equivalent which will as effectively open new opportunities for men and for capital, and make it possible for us to retain our constructive national psychology.

For the time being, we seem to be making the first and poorer choice. In some directions deliberately and in others by indirection we are slowing down our production of goods and services. In place of a confident advance toward business risk and personal adventure, we are all playing safe—business men, worker, and farmer. We are at this moment organizing a new world of restricted production, restricted human enjoyment, and restricted opportunity for the coming generation. We have chosen to play the lesser part.

We need not do this and we must not do it. For the effective equivalent of the old physical frontier lies ready at our hands for our occupation, development, and enjoyment. That frontier lies so close at hand that it escapes our notice. Its separate features are so familiar to us that we have missed its significance as a whole. For the new frontier is not a distant physical region, it is an ever-present social possibility. This new social frontier is ***a greatly raised standard of living for the mass of our fellow citizens.***

At first sight this proposal for a new frontier may seem trite and inadequate. But let us examine it before passing hasty judgment. Let us consider first and principally its material characteristics. Of what are they composed?

A higher material standard of living does not mean higher wages, higher salaries, or higher dividends. It does not mean higher prices for goods or services—least of all does it mean restriction of output. It does mean more and more goods and services at lower and lower prices relative to incomes.

Let us first consider whether a higher standard of living, defined in these terms, is physically possible. Next, let us see whether, if attained, it can take the place of the lost frontier in furnishing opportunity for youth and for capital, and in providing a favorable national psychology. Finally, if these inquiries lead to favorable conclusions, let us see what it is that prevents our occupation of this new frontier, so that we may remove the hindrances and proceed with our new social advance.

There can surely be no question as to the physical possibility of a rising standard of living. We have the material resources required. The very abundance of our coal fields, oil wells, and fertile soil have embarrassed our clumsy institutions until we have imagined abundance to be a curse instead of a blessing. For the materials we need and do not have there are ample stores of native products for exchange in the markets of the world.

We are favored as well in the character of our population. Drawn from a diversity of races, they bring to our land every useful type of acquired skill and native ability that could be asked for; and their energies are heightened by climates that are for the most part particularly favorable for effective work of hand or mind.

Finally, years of experience have produced in this country a body of business and technical experience directly adapted to the production and distribution on a large scale, at low cost, and with minimum human effort, of a rich variety of desirable goods and services.

The rising standard of living is physically possible.

Quite obviously, when we consider the matter, this new social frontier of the higher standard of living offers the same advantages as did the old physical frontier if we can but enter into and occupy it.

We seek more and better goods and services at less relative cost. This can only be effected to the desired degree by both expansion and refinement of our productive machinery and processes. The expansion of industry will call for more and more workers. The needed expansion and improvement of production will call for more and more investment. Only by this expansion of operations and revival of investment can we simultaneously produce more and better goods and services, distribute them more widely, do so at a less relative cost, and employ more men in the process at a number of working hours per week which tends to decrease rather than increase. All other programs fall short of this complete solution.

Our progress toward a higher standard will thus definitely provide the opportunities for men and for money that were furnished by the old frontier; and as this fact becomes obvious, it is plain that our old psychology of firmly based optimism will revive, and our newly injected defeatism will wither and disappear—a consummation devoutly to be wished for.

If this new social frontier is physically attainable, and offers a continuation of the services which were rendered to us for so many generations by the old frontiers, we must be in earnest in our determination to discover and surmount the obstacles which deter us from entering into it.

We have made good progress toward an ever-rising standard of living in the past, but in recent years our forward movement has been checked, and we have even been forced backward from our goal. The causes of our trouble have not been single, but many. But, of the many, two are of such overshadowing importance that it is folly to disturb ourselves about the minor difficulties until we have found means of surmounting these major ones. In fact, we cannot even see the other problems

clearly until these two have been solved. Thus attacked, the whole problem will more readily yield to solution.

The first obstacle is a false idea, and it is the more dangerous because it is held by a great majority of the population of the country. Business, labor, and agriculture account for almost the whole body of persons engaged in providing a high standard of living and all three of these groups are imbued with this false idea and strive to make it effective. That false idea is that the interests of each separate group are best served by control or restriction of output and by maintenance or raising of prices.

Industry has long been fascinated by the possibility of understandings between competitors which lead directly or indirectly to price and production control. So evidently profitable does this appear that the movement toward agreement and combination has been almost irresistible. As early as 1890 Congress recognized the rapid growth of the movement and passed the Sherman antitrust act forbidding "conspiracies in restraint of trade." But in spite of that legislation and of the succeeding Clayton act and the establishment of the Federal Trade Commission, business has, openly or secretly, consciously or unconsciously, moved in that direction. Some industries have, indeed, been so "successful" in coming to agreements that they have encouraged outside competition and quite evidently defeated their purposes.

Labor-union policy has been identical with business policy. But since the commodity dealt in is labor and skill, the fallacy is expressed in somewhat different terms. Labor-union policy seeks "shorter hours and higher wages" without any expressed or discernible limit. And some unions, like some businesses, have been so "successful" in this policy that their members are idle for months and years when other workers are profitably employed.

Agriculture has long looked with envy on the "success" of business and labor in carrying out this false idea and at last it too has its chance, under the AAA, to limit production and raise prices; and it too is meeting with the "success" of lost foreign markets, stimulated foreign competition, and actual importation of products which our farmers are well able to supply.

When business, labor, and agriculture hold the same beliefs, be they true or false, we must not be too surprised if the administration hastens to embody those beliefs in the law of the land. This was done, and as a result we had AAA and NRA. But legislation cannot purge a fallacy of its folly. These two institutions together lead to a universal condition of less goods at higher prices. But our goal of a higher standard of living requires more and more goods at relatively less prices. The governmental policy is surely false. It leads away from our goal. There is no magic algebra which can prove the truth of the equation, AAA + NRA = Prosperity. It does not equal prosperity. It equals a lowered scale of living for the people of this country, and no other answer to this equation can be found.

This first obstacle, then, is in the nature of a drag or brake or a heavy load to be carried. The second has more the nature of a recurring catastrophe which, when it occurs, not merely retards our advance but stops it completely. It not merely stops it, but throws us backward and destroys the very mechanism of progress, so that we must spend weary months and years in repairing it before we can regain our lost ground and resume our advance.

This second obstacle is the periodic onslaught of speculative frenzy to which our social organization is subjected.

We should clearly understand what we mean by "speculative." In the sense in which we are using the word it has no connection with business enterprise or business risk. A man may risk his time and all the funds at his command in the development of a new machine or a new product, or simply in an attractive business opportunity of the conventional sort. The outcome may be doubtful and may be called "speculative." But the proceeding is essentially healthy if pursued with judgment and in the light of experience. On the willingness of the business community to engage in such risks are based our hopes for expanding employment and a rising living standard. Speculation is quite another thing and is most unhealthy when carried out on a large scale. It will best be understood if we describe the conditions under which it flourishes.

Periodically business men become discouraged with the slow and meager profits of normal business, which is the business of producing and distributing goods and services. Normal business profits are small. If on the one hand we admire the returns from certain well-managed or especially fortunate organizations, on the other we observe the thousands of businesses which struggle along for years without profit, finally sinking into bankruptcy with losses which run to hundreds of millions in the aggregate. Between the two extremes lies the general average of business success which, with infinite work and worry, returns to its owners little more than the normal interest on the capital invested.

From time to time the business world, discouraged with this meager return, looks about and discovers lying ready at hand a marvelous mechanism which promises to work to a most attractive end. Instead of finding in his hands at the end of the year only the small profits of this year's business, this mechanism promises that the business man can hold in his hands to use or spend and enjoy *now*, not only the profits of this year but next year's profits as well—the profits of five years ahead—the imagined profits of future generations. This mechanism, ready at hand for such delectable use, is the speculative market for securities, real estate, and commodities, with the financial mechanism to which it is geared. The endeavor to realize far future profits by the use of this mechanism is "speculation" in the sense in which we are using the term.

When the professional speculators are joined by thousands of business men and finally by the general public in the operation of this mechanism, it does seem to work. For many months or for a term of years we do find new, spendable wealth in our hands—new millions,

new billions. Apparently, we can reach far into the future, seize its profits, and enjoy them now.

But it is in appearance only. There is no mechanism which will reach into the future and seize the profits of years not yet born. The reality is ugly and sordid. If there are new billions of "wealth," those billions came directly from bank borrowing by purchasers of the securities, real estate, or commodities, to finance their purchases above cash margins which were comparatively narrow. Bank-credit money, from its very nature, is generated by the process of borrowing and disappears when the debt is paid. In consequence, for every billion of new wealth there is somewhere a billion of new indebtedness, and if that billion of indebtedness becomes due and must be paid, then somewhere a billion of "wealth" must disappear.

That volume of indebtedness—that source of fallacious wealth—is an incredibly flimsy and fantastic structure when we reach the end of a protracted speculative boom. It finally becomes evident to every one that the future profits on which present prices are based can never be realized. When that does become evident prices fall and debts become due. And then, for long months and years every cent of savings, every mite that can be spared from the bare expenses of existence, must be devoted to the liquidation of that indebtedness. These sums are lost to purchasing power, and these months are months of destruction and defeat. The damage must be painfully repaired before we can again resume our progress toward the new social frontier, which is the raised standard of living.

These two obstacles, the false idea and the destructive calamity, are not light matters. We have struggled with them for generations, and they have grown stronger with the years. What hope is there that we will ever control or overcome them?

I am glad to stand before you tonight and to say that to me the prospect for sanity and intelligence in these matters looks brighter than at any time in the past. We have done much thinking. Experience has brought to us bitter lessons. Some of them we have learned.

We have, for instance, one example before our eyes of an industry which has never for a moment worshipped the false gods of production control and raised prices. The automotive industry has always been willing to submit to severe competition, and in consequence it has year by year built more and more and better and better cars and sold them for lower and lower prices. In further consequence it has made the greatest increase in employment and payroll dollars and is the most prosperous of any of our great industries. It has made the greatest contribution to industrial recovery. Other industries are taking notice and considering their ways.

Furthermore, there is a growing realization that if industries agree on price and production instead of competing, they open the door to government regulation. Indeed, under those conditions, government control becomes an inescapable duty. On the other hand, for an industry which submits to the hazards of competition, and governs its prices and output thereby, governmental control is an unwarranted impertinence and a social calamity. Viewed in this light, our antitrust legislation is the strongest protection available to business. These things are becoming clear, and if there is any drift of business opinion it is away from the fallacious search for safety, and toward intelligent courage.

Industry must lead the way. We cannot expect labor or agriculture to do so. The prosperity which will come to industry as a whole in so doing will so directly increase the demand for labor and for agricultural products that the artificial methods hitherto applied by these two groups will be clearly seen as the hopeless proceedings which in reality they are.

As to the control of speculative frenzy, we can point to much more definite items of achievement. Beginning with the Glass-Steagall act of the last months of President Hoover's administration, and ending with certain useful elements of the banking act passed last summer, we have provisions which by no means insure us against a recurrence of this calamity, but which do provide us with tools which, if wisely used, will greatly diminish the severity of any future attack.

Hitherto it has not been possible to restrain the expansion of speculative credit without throttling the flow of credit for normal business in the process. Now, for the first time, we can restrain the evil while supporting the good. We need have no repetition of the period from 1926 to 1929 with its disastrous consequences. We can, if we will, prepare a future freed of the worst follies of the past, in which we can move steadily and purposefully toward our social objective of a raised standard of living for our people as a whole.

It must be clear to all that engineers have a particular interest and responsibility in these matters. We cannot sit idly by and see the choice made for us.

If, faced with the disappearance of the physical frontier, we cravenly resign ourselves to accepting that fact as final, and key our national policy and our national hopes down to that dismal decision, there will be little future for the engineer. There will be fewer of us, and our services will be of a subordinate order.

If, on the contrary, we make the more courageous decision to replace the lost physical frontier with the new social frontier of the raised standard of living, then the engineer will come into his own.

For the raised standard of living demands more goods and services, of better quality and at lower cost. This is the service which the engineer is qualified to render. To this was he born; for this was he educated; this is his life work. In a society dedicated to this end he will find profitable employment, satisfying recognition, and useful essential service of the general good. With the scientist, the inventor, and the broadly visioned business executive he will pioneer in the founding of a new order as far surpassing our present one as that does the barbarism of earlier ages.

We are faced with these alternatives—to retreat or to advance. Is there any doubt as to which the American people should choose? Nay, rather, is there any doubt as to which they *will* choose?

AS SAN FRANCISCO-OAKLAND BAY WILL LOOK IN 1937

(Upon an aerial photograph of San Francisco Bay, with Oakland in the background, the San Francisco-Oakland Bay Bridge has been drawn in to scale. The world's largest bridge, nearly four miles over water, will connect Alameda and San Francisco counties. To the north of Yerba Buena Island is shown a prospective view of the 1937 Bridge Exposition Island soon to be built. The west half of the bridge is a suspension structure comprising twin suspension bridges anchored into a concrete tower in the center.)

The SAN FRANCISCO-OAKLAND BAY BRIDGE

By C. H. PURCELL

SAN FRANCISCO, CALIFORNIA

SAN FRANCISCO is a peninsula, containing 42 sq miles, and protrudes from the continent of North America at about the same latitude as Chesapeake Bay.

San Francisco Bay is a two-pronged fork, one prong extending due east into the land to join the Sacramento River, and the other prong bent south to isolate San Francisco on the north by the one mile of water across the Golden Gate and on the east by four and one-half miles of water between San Francisco and Alameda County.

San Francisco is building two bridges to end its isolation. The Golden Gate Bridge spans the one-mile channel to the north, and the San Francisco-Oakland Bay Bridge spans the four and one-half miles of deep water between San Francisco and Alameda County.

In discussing the San Francisco-Oakland Bay Bridge we are discussing much more than the construction of a single bridge. This bridge may be more properly spoken of as a continuity of projects involving elevated highways or viaducts over land, an elevated railway connecting to a bridge, twin suspension bridges, each with 2310-ft main spans, a tunnel through an island—of larger bore than tunnels heretofore undertaken—a 1400-ft cantilever span, five through-truss spans, 14 deck-truss spans, a sand fill, an interlacing viaduct to distribute traffic in three directions without left-hand turns or right-angle crossings, and miscellaneous other viaducts and underpasses to distribute efficiently and safely the automobile traffic on three main approaches in Alameda County on the mainland.

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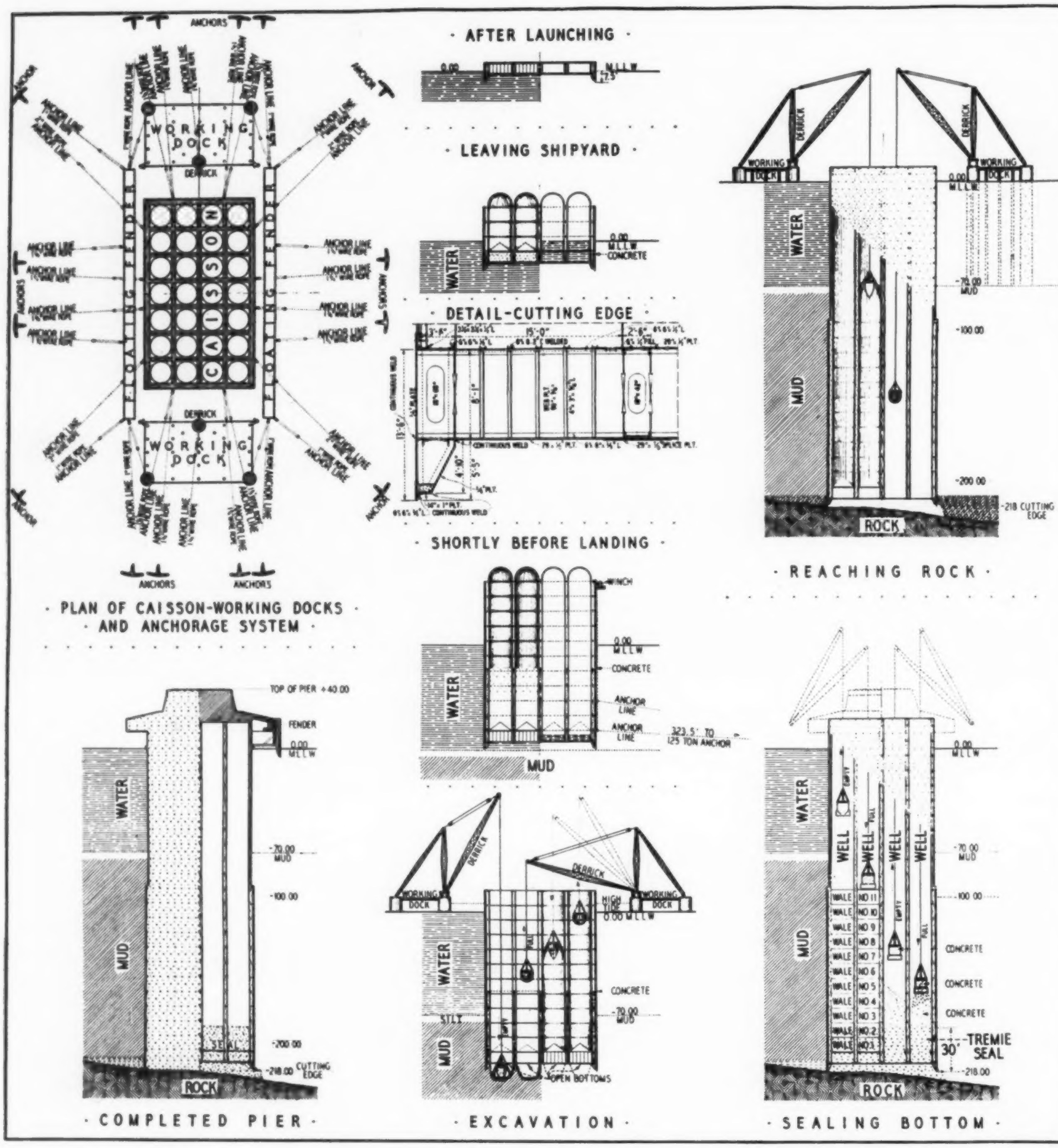


DETAILS OF PIER OF THE SAN FRANCISCO-OAKLAND BAY BRIDGE AND METHOD OF SINKING COMPRESSED-AIR-FLOTATION CAISSON

THE PROJECT

To give a general picture before we discuss its features, the bridge spans four and one-half miles of navigable water and, in the center, crosses a 400-acre island which rises to a height of 340 ft above the bay, and which is largely of fractured sandstone.

San Francisco, with a population of some 700,000, is at the west end and Alameda County, comprising the cities of Alameda, Oakland, Berkeley, and lesser towns having a combined population of about 550,000, is at the east end. The island divides the bay into a West and East Bay crossing.

The West Bay crossing is approximately two miles, and over this channel we are building twin suspension bridges joined together to a common concrete center anchorage against which the twin bridges pull in opposite directions. The twin suspension bridges have main spans of 2310 ft in length and side spans 1160 ft long.

On the San Francisco side we have a 68,000-cu yd concrete gravity anchorage from which radiate three ramps to distribute the traffic into the densely populated city.

The bridge is double-decked throughout; each deck is 58 ft wide from curb to curb.

The lower deck provides space for two interurban tracks to carry trains of 70-ton cars, and 31 ft for three lanes of trucks

up to a maximum weight of 40 tons. The upper deck provides six lanes for automobile traffic. No pedestrian provisions are made on this toll bridge.

The center anchorage, in which are anchored the two pairs of cables of the twin bridges, is a tremendous concrete structure with a total concrete content of some 160,000 cu yd, and with a height from bedrock that amounts to approximately five hundred feet.

The cable anchorage on the island is of the tunnel type, two 165-ft tunnels providing for the concrete-embedded eyebars.

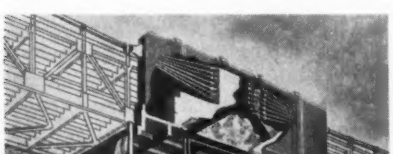
The vehicular crossing over the island is accomplished by a tunnel, 540 ft long, through the island, which involved an excavation 60 ft high and 80 ft wide, and when lined with concrete is 53 ft high by 66 ft wide.

The remaining 2400 ft of the island crossing consists of concrete and steel viaduct for the two decks of the bridge, part of which is the 500-ft anchor arm for the cantilever span.

The 19,400 ft of East Bay crossing is accomplished by a 1400-ft cantilever span, five through-truss spans, and fourteen 288-ft deck-truss spans which are brought down to ground level by means of some short girder spans that lower the upper deck between the forks of the lower-deck truck lanes.

A dredged-sand fill, approximately one mile long, extends outward from the east side to join the end of the bridge proper, and upon this sand fill the toll houses are being built.

On the Alameda County shore at the east end are a complicated distribution structure and two underpasses that are being provided for the three main arteries of the bridge traffic.

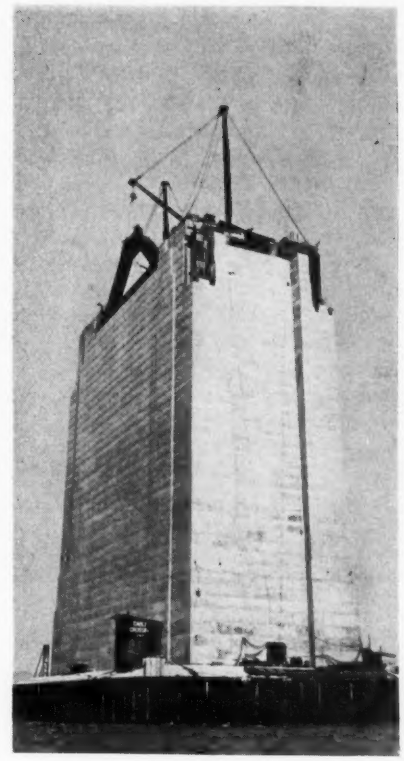


THE "INSIDES" OF THE CONCRETE CENTER ANCHORAGE MIDWAY BETWEEN SAN FRANCISCO AND YERBA BUENA ISLAND ON THE SAN FRANCISCO-OAKLAND BAY BRIDGE

HISTORY OF PROJECT

To relate the history of the San Francisco - Oakland Bay Bridge, one could start almost with the earliest beginnings of the City of San Francisco. San Francisco was formerly called Yerba Buena, but changed its name, I believe, about 1845. In 1849 California had its gold rush, and in 1850 California became a state. In the sixties the nearby Nevada gold and silver bonanza stimulated San Francisco's growth.

In 1868 Leland Stanford suggested that his Central Pacific Railroad build a bridge between San Francisco and Alameda Counties. This plunging railroad builder, flushed with success over the completion of the last link of the railroad between the east and west coasts of America, rashly proposed to build a bridge twice as wide as the one we now undertake, so that he could accommodate not only such traffic as then existed, but also popular resorts, saloons, and moonlight promenaders. Stanford believed he could build the bridge for five and one-quarter million dollars on foundations of stone. It must be remembered that this was before the construction of the Brooklyn Bridge. Use of metal was then just beginning to revolutionize building methods, and this stimulated the bridge-the-bay movement.



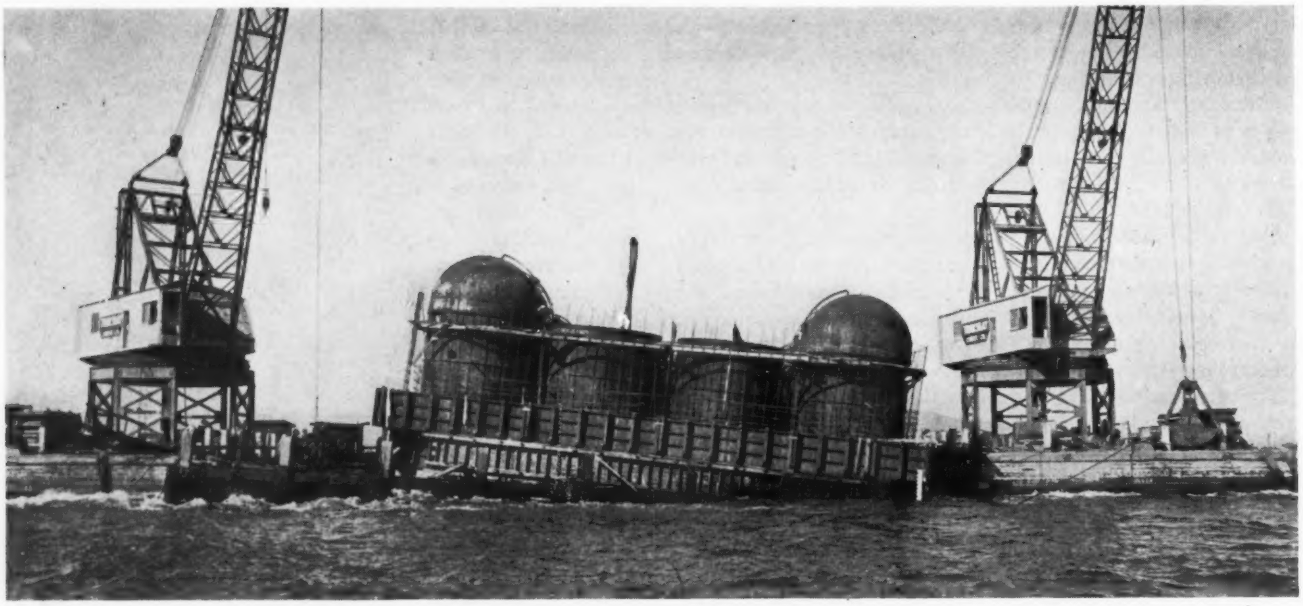
CONCRETE CENTER ANCHORAGE OF THE WEST BAY CROSSING

(The height of the concrete center anchorage from water level to top of concrete is 235.18 feet.)

Needless to say, Mr. Stanford never attempted to realize his dream, and it is probably just as well that he didn't try. But San Francisco continued to talk of bridging the bay for the next two generations, and in the meantime a remarkably efficient ferry system developed to carry the tremendous daily commuting traffic over San Francisco Bay. The ferry boats were designed to carry both automobiles and passengers. In 1929 passenger ferries carried 35,900,000 foot passengers across the bay, and 4,490,000 vehicles, in which there were an additional 10,000,000 passengers. The depression decreased this traffic to 26,027,354 foot passengers and 3,604,111 automobiles, in which there were 9,700,104 additional passengers in the year 1934.

Approximately fifty thousand persons living in Alameda County, or "the East Bay," travel daily to San Francisco to places of employment and return in the evening. Such a traffic total naturally inspired private promoters to seek some means of financing a bridge as a substitute for the ferry boats. The private promoters who sought a franchise from the San Francisco board of supervisors or councilmen numbered as high as 35 rival firms and individuals in 1926. By 1927 some of the leading citizens of the city took cognizance of the bridge situation and laid it in the lap of the state government.

By 1929 the legislature of the State of California created a California Toll Bridge Authority, which is a commission of five members headed and controlled by the governor, with powers to buy, build, and finance bridges anywhere in California, providing the bridges can be financed by revenue bonds against their tolls, without any aid from the taxpayers. The Toll Bridge Authority is contemplating tolls of 50 cents per automobile, without extras for passengers, a graduated weight schedule for trucks and motor-truck freighting, and a toll of $2\frac{1}{2}$ cents for each rail passenger carried over the bridge railway. We anticipate that these revenues will amortize the investment



COMPRESSED-AIR-FLOTATION CAISSON IN PERIL

(This photograph of the caisson for Pier W-6 was taken on January 25, 1934, after it had tipped suddenly to the east, its east side eight feet lower than its west side.)

of $77,600,000 in from 20 to 30 years. Whether we shall charge this generation a high fare so that the next generation may have a free bridge, or whether we shall lower the tolls so that both this generation and the future generation shall each pay a part of the principal, is a question as yet unanswered.

At the time the California Toll Bridge Authority was created, I was made chief engineer and given the problem of bridging the bay. In 1929 President Hoover and Governor Young, of California, formed a joint commission as a result of suggestions from George T. Cameron, publisher of the *San Francisco Chronicle*, and Bert B. Meek, then director of public works of the State of California.

This commission studied the routing and destinations of traffic over a period of years; established by borings a route for the bridge to take across the bay, and recommended that the state undertake such a structure. The state then appropriated $650,000 to complete the design of the bridge. In 1932 the design was completed, but the bond market had collapsed, and we were faced with the impossibility of selling the revenue bonds. Fortunately, however, the Government was considering restoration of credit, and the Reconstruction Finance Corporation was created in the early part of 1932. In the spring of that year, amendments to the Reconstruction Finance Corporation Act providing for the financing of self-liquidating projects of a public nature became part of the law, and the Reconstruction Finance Corporation door was opened to us to make our application. During that year our application was approved, and on December 15, 1932, the contracts were signed by the California Toll Bridge Authority and the Reconstruction Finance Corporation for financing the construction of the bridge by purchase of our bonds.

The California Toll Bridge Authority issues $4^3/_4$ per cent coupon bonds which are purchased by the Reconstruction Finance Corporation, with a rebate to yield 4 per cent. These bonds are purchased in blocks of three and four million dollars, as needed for construction purposes. To date, October 31, we have spent $34,698,570 on the bridge, and have received $35,814,778 from the Reconstruction Finance Corporation by the sale of bonds, to a total face value of $37,000,000.

Ground was broken with the joint participation of former President Herbert Hoover and President Franklin D. Roosevelt on July 9, 1933.

To date the entire substructure has been completed, the westerly cables of the twin suspension bridges have been spun, and all of the East Bay crossing has been built except the 1400-ft cantilever of which one anchor arm and one cantilever arm have been erected. The excavation for the tunnel has been completed and lined with concrete.

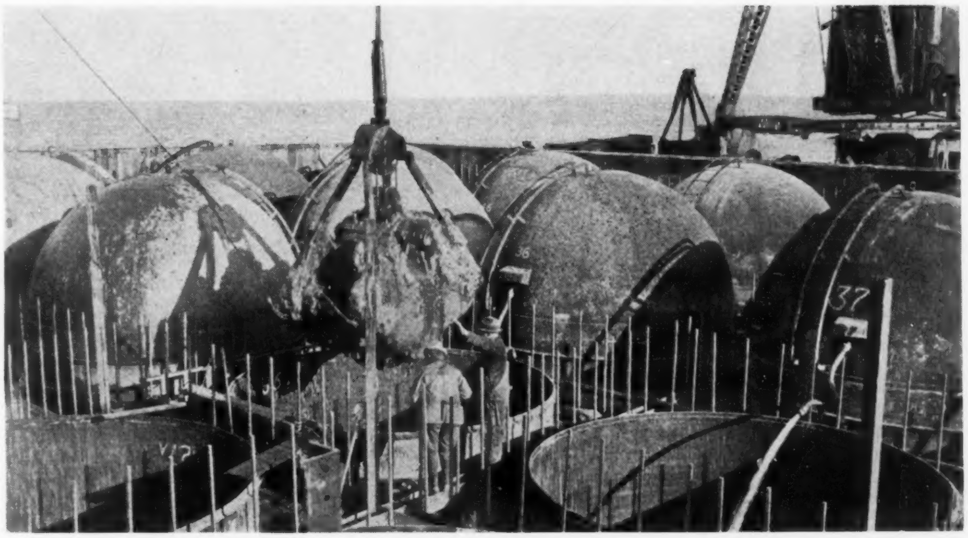
In discussing the methods of construction, I shall divide the bridge into the substructure and the superstructure, the anchorages, and the cables.

RESISTANCE TO EARTHQUAKE SHOCK

As to the substructure, it is of interest to note the provisions against earthquakes. All foundations are designed to resist a lateral force equal to ten per cent of the acceleration of gravity. This is twice the earthquake design factor required by earthquake-proof buildings. We tell any anxious San Franciscans that while they may never have another earthquake for years for the reason that the last one probably relieved the tension which caused the fault, yet should there be a quake during the life of this bridge, it would have to be severe enough to shake down all the buildings of the cities at either end of the bridge before it could destroy the bridge itself. This may be an optimistic statement, but research on this subject proves to our satisfaction that the bridge is better designed than buildings to resist earthquake shocks.

The San Andreas fault, which was responsible for the fire of 1906 in San Francisco, runs almost parallel to the coast line of California, missing San Francisco County, however, as it passes out into the ocean in a northwesterly direction. This fault passes eight miles due west of the San Francisco-Oakland Bay Bridge, with the entire city of San Francisco between.

The subject of earthquakes is one which engineers of the past once ignored as acts of God that no structure could attempt to measure; similarly certain regions were deemed to be earthquake regions and others were regarded as immune to this disaster. Both of these old beliefs are being rapidly dissipated.



TOP OF THE CAISSON SHOWING HEMISPHERICAL DOME CLOSING THE INDIVIDUAL CELLS

($3^1/_2$-yd clamshell bucket loaded with mud emerging from one of the 15-ft diameter dredging wells of caisson No. 4.)

Earthquakes are occurring in unexpected places, and sudden movements of masses of the earth's surface seem quite likely to happen almost anywhere. However, when building adjacent to known fault lines where earthquakes of severity have occurred, an engineer is justified—indeed, I may say, an engineer is commanded—by these known conditions to design any important structure in that area to resist the greatest shock within the allowance of other factors. Most damage from earthquakes has occurred on filled or alluvial-deposited land, while structures founded on good rock have in a large part escaped great damage.

The piers beneath the suspension bridge in the West Bay crossing are built on shale rock capable of bearing 25 to 30 tons per sq ft. These piers penetrate from 50 to 107 ft of water, and then an additional 50 to 150 ft of soft mud and clay of varying stiffness and sand. A pier founded on rock moves with the rock. The mud and water resting above the rock perhaps remain more or less inert. Considering the worst condition—that is, if the mud and water remain inert—the pier, being moved laterally with a quaking rock, will plough through the mud and water like a blunt-nosed ship.

In designing the bridge for earthquake strength, this ploughing action of the pier in an earthquake has been taken into consideration, and I think perhaps our calculations on this subject are new to earthquake engineering. The weight of the pier is, of course, the measure of its resistance to this earthquake movement; and the weakest point of the bridge from an earthquake standpoint is designed to resist a horizontal force equal to 10 per cent of the acceleration of gravity, or 3.22 ft per sec per sec.

Our study of assembled records of the Tokyo earthquake, one of the most severe quakes of which I have knowledge, convinced us that an assumption of a force of 10 per cent of the acceleration of gravity is ample.

For structures founded on rock capable of sustaining four or more tons per square foot, the earthquake investigation committee of the American Society of Civil Engineers recommended resistance to stresses equal to four per cent of gravity. From this it will be seen that our piers have a safety factor two and one-half times that recommended by the A.S.C.E.

A second point upon which we have pushed research further, I believe, than has heretofore been undertaken in connection with earthquakes, is the study of the action of horizontal forces upon the flexible portions of the bridge. By use of such formulas as were available, we have established methods for calculating earthquake stresses along the stiffening trusses, both for earthquake movement parallel to the bridge and transverse to its longitudinal axis. We find that a suspension bridge is better fitted to resist an earthquake than a rigid steel-frame building of earthquake-proof construction, because of the former's flexibility and the guying of its towers by the suspension cables. A suspension bridge is similarly better fitted to resist earthquakes than a

CUTTING EDGE FOR CAISSON W-3 SHOWING ADAPTER SECTIONS TO WHICH CYLINDRICAL CELLS ARE WELDED

(Pier W-3 is 240.7 ft below water level and supports a steel tower 519 ft above water level, which makes a structure 759.7 ft from its foundation to its topmost point.)

AERIAL PHOTO WITH STRUCTURAL-STEEL SUSPENSION TOWER IN FOREGROUND, WITH ITS CATWALKS CONNECTED TO THE ANCHORAGE ON YERBA BUENA ISLAND; THE VEHICULAR TUNNEL THROUGH THE ISLAND; AND BEYOND A 1500-FT GAP IN THE BRIDGE

cantilever bridge, due to the rigidity and higher center of gravity of the latter. The unadorned structural-steel members of our bridge, which are not curtained in masonry at any point, have a distinct advantage in this condition over earthquake-proof buildings with curtains of masonry reaching up to great heights. As a matter of fact the design division on the bridge would not consider for a moment curtaining the steel towers in masonry, and I am safe in saying that bridge engineering and structural engineering as practiced in skyscrapers are far apart. The practices of the builders of skyscrapers would not be countenanced on a good bridge. The wedding of flexible and nonflexible materials, without regard to their natural incompatibility, seems to a bridge engineer to be fraught with marital troubles.

CONCRETE CONSTRUCTION

SUBSTRUCTURE AND ANCHORAGES

The unusual character of the foundations of this bridge, with particular reference to the great depth to bedrock, required development of new methods of sinking caissons. The size of the bond required, involving two processes, made it necessary for the engineers of the Bridge Authority to furnish complete details of design of caissons and method of sinking foundations. Contractors were not permitted to use alternate methods in their bidding. This was done to prevent a bid on a design that would not accomplish the work, although permitting the contractor to become low bidder. Therefore, in this case the responsibility for the success of the foundation construction, providing the contractor proceeded in accordance with plans, rested upon the engineers of the Bridge Authority.

Another important specification feature was the fact that it really required a showing of a million and a half dollars in quick assets or cash by the contractor, in addition to his bond for the equipment account. The object of this was to assure an adequately equipped job, which is so essential to the success of large undertakings. The prequalification law permitted us to limit the contractors bidding to those who qualified on the basis of experience and quick-asset resources. When it was realized that some of these cofferdams and caissons represented an investment of a million dollars when they were landed and before sinking began, these precautions were deemed necessary.

The two-mile West Bay bridge follows a ridge of bedrock rising below the surface of the bay to an elevation higher than the surrounding contour of the bedrock of the bay by a maximum of 150 ft and an average of 50 ft. On this ridge it was possible to find rock at elevations from 100 to 233 ft below low water. Others of the five possible routes studied would have required piers as deep as 350 ft in the West Bay channel.

For the two-mile crossing, the twin suspension bridges with a common central anchorage were determined to be, in our opinion, the best design for spanning this channel, as will be brought out in discussion of the superstructure in the following pages.

The water depth ranged from 12 to 107 ft at mean lower low tide selected as datum. The tide itself has a six-mile-an-hour flow, and rises and falls about six feet. The character of the mud at the bottom was such as to resist scour.

In boring, a large number of 2-in. and 5-in. undisturbed samples were taken every 10 ft of elevation by means of sampling devices.

Upon the ridge of bedrock the superstructure design required the building of five piers, the center one of which is a huge concrete common anchorage with an unusually large perimeter —92 by 197 ft—the others ranging in plan from 52 ft by 121 ft 4 in. for pier W-2 on the San Francisco shore line to pier W-6, 74 ft 6 in. by 127 ft in plan where bedrock is at elevation —175 to —183.

For the most westerly pier, going to 100 ft below water line, the steel sheet pile cofferdam was designed.

When we contemplated sinking piers almost 250 ft below water we realized that the pneumatic caisson, under which men in air pressure accomplished the excavation, was impossible of application to this job because men cannot work farther below water than 125 ft. Men did not go down below the caissons in the water except in the case of a diver in a diving suit who went down to make final inspections before the concrete seal was poured.

For the other four piers, three of which established world records for depth and size, special considerations of design were required.

COMPRESSED-AIR-FLOTATION CAISSON

A modified form of the cellular open-dredging-well caisson was selected as the most feasible, and a special type was designed by our staff and consulting engineers. This design, which we named the compressed-air-flotation caisson, involved an open-dredging-well caisson with cylindrical cells, 15 ft in diameter, composed of plate-steel pipe upon which were welded hemispherical domes to entrap air and thus provide control of buoyancy.

The cutting edge at the bottom of these caissons was assembled in dry dock on shipways. The cutting edge for these caissons was composed of steel box girders 13 ft 6 in. deep. These girders were welded into a rectangular perimeter with interior girders of the same dimensions running both directions, dividing the space into 15-ft squares. Thus, the cutting edge was a system of cells, open top and bottom, and 15 ft square, walled off by box girders closed at the bottom to displace sufficient water to float this steel structure.

On the smallest of these caissons the cutting edge consisted of three rows of seven cells 15 ft square; on the largest, of five rows of eleven cells 15 ft square.

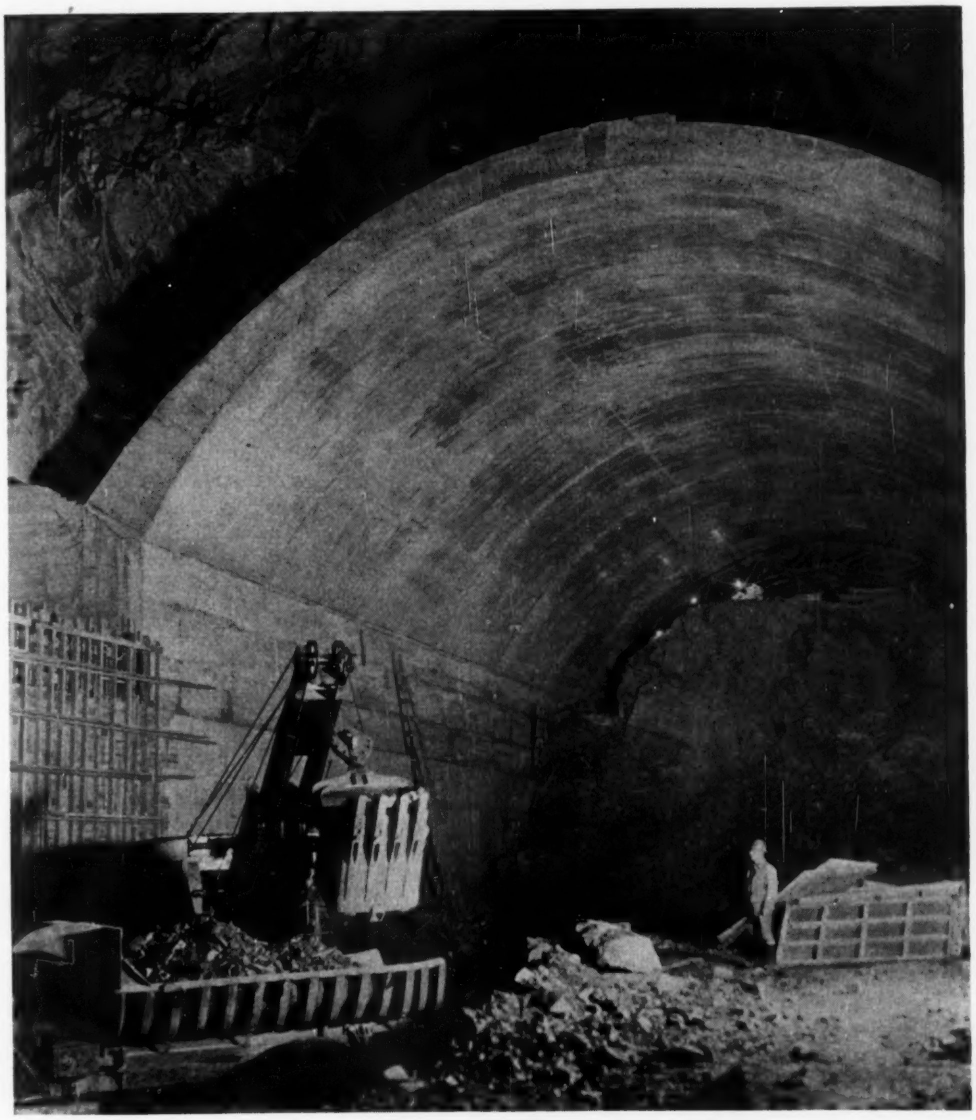
Adapter sections were welded onto each of these 15-ft cells to reduce the squares to cylinders 15 ft in diameter. To these adapter cones were welded 20-ft sections of cylinder, 15 ft in diameter and upon the cylinders were welded hemispherical domes of $^3/_8$-in. plate steel. The domes were airtight and fitted with a valve for compressed-air hose connections.

Above the steel cutting edge the cofferdam of the caisson was of timber sheeting composed of 10-in. timbers set vertically, and upon them 4-in. creosoted sheeting applied diagonally and calked watertight.

No timber was used in the interior of the caisson, thus facilitating setting up reinforcing steel rods between the wells before the pouring of the concrete. These cutting edges were launched with only the adapter cones attached and the cylinders were welded on during flotation. The steel wells and exterior sheeting were erected to a height of 60 ft above the box girders of the cutting edge before it was towed to the site. From two to four tugs towed these caissons to their locations. The largest of these caissons weighed nearly 6000 tons at this time.

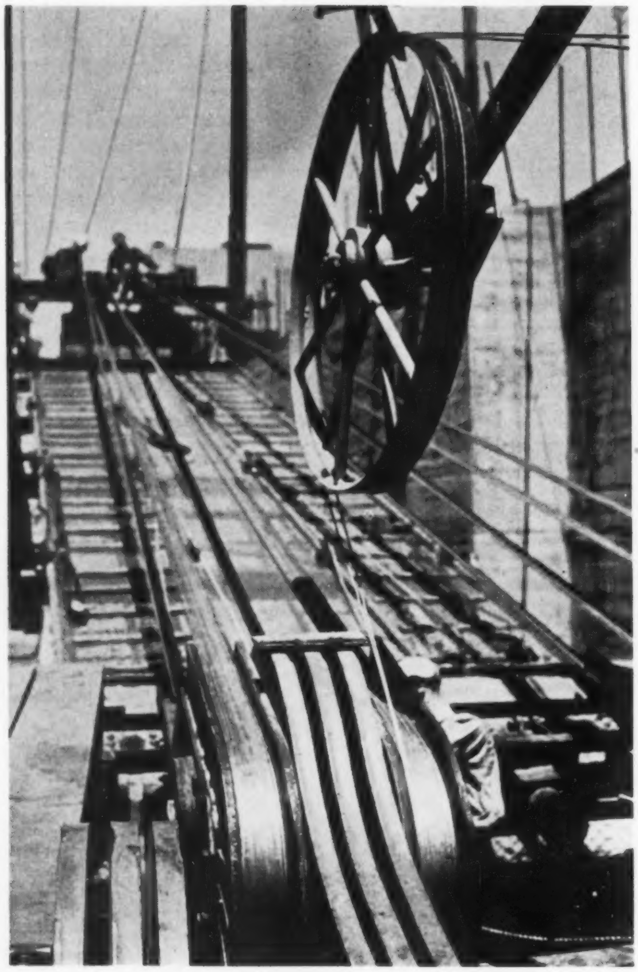
Prior to the location of the caisson, some 24 concrete anchors, T-shaped, and weighing from 18 to 25 tons each, and equipped with jetting pipes along the lower edge so that they could work their way deep into the mud, were barged out and dropped around the site for the caisson. To these anchors, lines had been attached extending up to buoys, or markers. When the caisson was towed to site, lines were detached from the buoy markers and attached to hand winches on the sides of the caisson so that they could be adjusted. These anchor lines, radiating in all directions from the caisson, made it possible to move it over and adjust its location frequently during the floating stage.

During the floating stage, concrete was poured in the caisson around the cylinders until the cutting edge of the caisson sank to within 5 ft of mud bottom. Adjustments were made in the caisson's position by triangulation and then enough of the air in all the cylinders was released simultaneously to allow the caisson to drop suddenly into the mud, its cutting edge generally penetrating more than 5 ft immediately.



VEHICULAR TUNNEL WITH A BORE OF 140 FT

(Because of the dangerous nature of the rock structure, the sides were constructed before the rock core was removed.)



SPINNING THE SOUTH CABLE—SAN FRANCISCO ANCHORAGE
(Nineteen wires in place on four strand shoes. Spinning wheel may be seen in upper section of photo.)

When a caisson was to be landed on mud, its concrete walls brought up to a few feet below water line. After the cutting edge was firmly embedded in the mud, the domes were removed a few at a time, leaving the open and domed wells in symmetrical formation, and excavation by means of from two- to four-yard buckets was begun. These buckets (clamshells or orange peels) were lowered by derricks into the open wells to dredge out the mud from beneath the caisson, allowing it to sink toward bedrock.

When the cutting edge was within 10 ft of bedrock a trench was dug under the middle of the caisson beneath two rows of wells. This trench was cleaned out to solid bedrock by means of jets, and concrete was dumped by means of bottom-dump buckets on the bedrock to build a floor underneath the caisson. Another trench in the transverse direction along the middle of the caisson was dug and concrete poured so that the caisson had a cross-shaped floor of concrete to rest upon.

Eventually the entire surface of the bedrock underneath the caisson was jetted and chiseled clean and a floor of concrete poured on the uneven surface of the bedrock for the caisson to rest upon. This hydraulic concrete seal was poured from bottom-dump buckets of 4 cu yd capacity. When these buckets landed on the bottom, they opened and let the concrete slide out easily without mixing with the water that was in the wells.

This completed the operation of sinking these compressed-air-flotation caissons.

PROBLEMS IN SINKING CAISSONS

Sinking the caissons produced a parade of engineering problems. It was necessary to keep the center of gravity low to avoid tipping these tall structures and yet maintain the necessary weight. At the same time it was necessary to provide ample freeboard, and a minimum of not less than 15 ft was required at all times. Because of the alternate strata of resistant and nonresistant material supporting the caisson, we had to be prepared against the possibility of the caisson's suddenly dropping faster than its cofferdam and cylinders could be heightened; and because of the difference in the supporting capacity of the material beneath the area of the cutting edges, we frequently had caissons hung up on ledges of tough material and hanging loosely in soft material on another corner. Only on two occasions did this condition produce tipping of a serious nature.

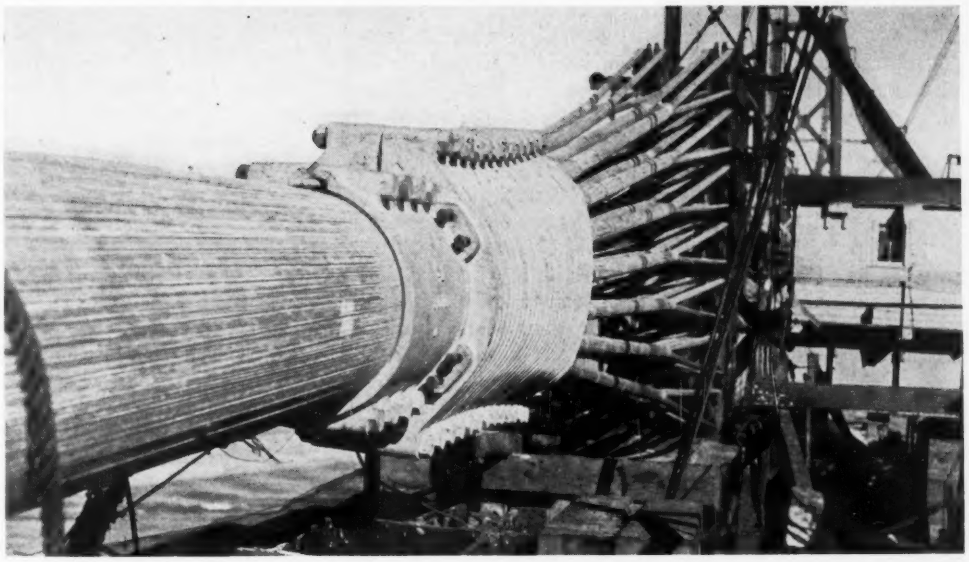
The largest caisson, 92 by 197 ft in plan, weighing at time of tipping 73,000 tons, while its cutting edge was at an elevation of minus 97 ft in 71 ft of water, encountered a soft blue sandy clay, and after all the domes had been removed was on even keel, with the mud extending up into the cylinders from 9 to 15 ft above the cutting edge. At this time the north cutting edge over a period of three hours sank $8^1/_2$ ft, and the south cutting edge $2^1/_2$ ft, so that when the movement virtually stopped there was a list to the north, that edge being $5^1/_2$ ft lower than the south. The compressed-air cylinders came to our rescue in this situation. Domes were replaced on every alternate cylinder of the outside rows and air pressure was raised to 15 lb per sq in. while another five-foot lift of concrete was poured to add weight to the caisson. The air pressure was then reduced from 15 to 8 lb per sq in. in the south cylinders; that is, on the high side, and a settlement of 0.1 ft was accomplished. Another five-foot lift of concrete was poured some days later and all the air was released on the south or the high side, and the air pressure increased to 20 lb per sq in. on the north side. In addition, four more cylinders were domed on the north side and air pressure increased in all the north cylinders up to 28 lb per sq in. In spite of this, the north cutting edge on the low side continued to sink at a more rapid rate than the south. Two days later the north side had increased its list to approximately $7^1/_2$ ft and the mud in the north cylinders had risen to 23 ft above the cutting edge. To add to our troubles the mud in these north cylinders had formed a plug or false bottom which rendered the air ineffective because it could not exert its buoyancy factor against the actual bay bottom. The pressure on the mud bottom on the low side caused an outward flow of mud from under the north cutting edge, which raised the center part of the north working dock four feet above its previous level. Two days later the list had increased to $8^1/_2$ ft. The north side was still low, and at this point settlement stopped. Then a second row of cylinders on the north side were domed and pressure was raised to 18 lb per sq in. This apparently stopped the downward movement on the north side. The limit of the effectiveness of the compressed-air system had been reached, and it was apparent that the next step should be to lighten the caisson on the north side and at the same time exert a horizontal pull in a southerly direction at the top of the caisson.

Syphons were placed in the north cylinders then, and the water lowered about 20 ft in these low-side cylinders, one at a time. At the same time water was being pumped into the cylinders on the high side.

The original anchor lines were attached to the high side

and drawn taut. Some dredging was then started in the cylinders on the high side of the caisson and, assisted by unbalanced air and water and aided by the pull of the anchor lines, we succeeded in starting a major righting movement of startling suddenness. Within a period of 36 hr the caisson sank only half a foot on the north, or the low side, and 16 ft on the south side, with the result that the list was now reversed, and the south side was a little more than 8 ft below the north side.

We thus were required to reverse our tactics, and pressure in the south cylinders was raised to 37 lb per sq in. and additional concrete wall was poured. Dredging was begun in the high north cylinders and immediately started a righting movement. As the caisson righted itself we reduced the air in the cylinders under the low side.



THE END OF THE $28^3/_4$-IN. SUSPENSION CABLES OF THE SAN FRANCISCO-OAKLAND BAY BRIDGE, SHOWING THE $7^1/_4$-TON SPLAY CASTING, WHICH BINDS THE 37 STRANDS INTO CONICLE SHAPE AND RESISTS THE GREAT BURSTING PRESSURE

(The splay casting is $43^1/_2$ in. across at the large end and $28^3/_4$ in. in diameter at the small end and was one of the most difficult castings to manufacture on the entire job.)

It is interesting to note that the sinking forced the mud up into the cylinders and built up the air pressure approximately 2 lb as the high side tipped back toward even keel. During this wallowing movement, which was a period of great concern to the engineers and contractors, the caisson sank from elevation —103 to —130 over a period of 19 days, and moved $1^1/_2$ ft west and $^1/_2$ ft north. Its cutting edge at the bottom passed through clay mixed with shell and some sand, and brought up a clay stratum with a high sand content and was again level at elevation —138.

From this point on our troubles were little ones. I relate this in order to give you a history of one of our two major tipping incidents. We met these exigencies by utilizing the compressed-air cylinders of these specially designed caissons.

WELDING AND CONCRETING

Now let me go back and discuss the methods of construction and the machinery. The original steel cutting edges were welded together by stitch welds. The contractor building these cutting edges elected welding rather than riveting for the fabrication of the steel cutting edges. The adapter cones, changing the shape of these square cells to round, were necessarily welded on because these had to be airtight. Similarly, the steel cylinders were welded on, and the welding of these cylinders and the domes on their tops constituted one of the greatest welding jobs ever undertaken. It has been calculated that there were 120 miles of $^3/_8$ in. continuous electric fillet weld in the four caissons for the West Bay crossing. Some one has calculated that these 20-ft sections of 15-ft tubes thus welded together in all these caissons would, if joined end to end, have a height of more than four miles. I am not a welding authority, so I shall not discuss the details of our welding experience other than to relate that it was virtually all electric arc, and that we used shielded rods. Without the electric-welding developments, the dome method of sinking would have been very difficult.

The concrete pouring was unusual and involved unusual quantities, some 800,000 cu yd going into the substructure alone. Because a maximum flow of 2000 yd per day was necessary during certain critical stages, a fast ready-mixed water-borne concrete traffic system had to be created.

A company undertook a subcontract from both the East and West Bay substructure contractors to furnish ready-mixed concrete from special mixer barges at caisson sites. Any delay was costly and so tense were the builders at times that sharp quarrels broke out over concrete deliveries which ended in both the caisson builder and the concrete man installing electric delay-responsibility detection systems with which to settle arguments.

A central batching plant at the railway terminal on an East Bay wharf was built, consisting of elevated bins of bulk cement and aggregate, automatically operated. Cement and aggregate went through electric weighing machines, recording automatically the weight of each material. After passing the batching devices, the cement and aggregates in $3^1/_2$-cu yd batches were loaded by conveyers into the fleet of electrical mixer barges at the wharf. The barge had some 44 bunkers for sand and gravel, and in the center of each bin was a can for cement of the proper proportion for the aggregate. When bunkers were filled, the barge was towed out toward the caisson and mixing would be started.

Mixed for $3^1/_2$ min, the concrete was elevated by conveyer belt to hoppers alongside the caisson, which either discharged the concrete into bottom-dump buckets or pump cretes, the latter of which forced concrete through 8-in. pipes into caissons at a rate of 50 cu yd per hr; and inside the caissons around the tubes men set up one-inch reinforcing rods and vibrated the concrete with internal electric vibrators. Several types of vibrators were used and generally all proved successful. One group was operated by electricity and had a speed of about 5000 rpm. Air was also used as a motive power for some of the vibrators, and in this case the speed ran from 8000 to 10,000 rpm. On some of the machines the motor was an integral part of the vibrator which made a rather heavy unit

to handle. On others, the vibrator was driven by a flexible shaft, which avoided the necessity of transporting the motor. The latter was favored by the men, but met with some difficulty as to maintenance. Future developments may eliminate this.

EAST BAY PIERS

The three deep piers of the East Bay crossing, built in water not deeper than 50 ft, made possible the use of ordinary false-bottom, open-dredging-well caissons. These were built to great depths, however, pier E-3 having its seal at a maximum low point of —242 ft and an average elevation at the bottom of —235 ft. Piers E-4 and E-5 have their seals at average elevations of —177.8 and 177.2 ft, respectively, and a maximum depth of —183 feet.

During the dredging operations at pier E-5, one of the buckets brought to the surface what at first appeared to be a stone between 6 and 8 in. in diameter and which on examination proved to be the well-preserved tooth of a mammoth that had roamed this region something more than 25,000 years ago. The tooth was found at 180 ft below water line. It had obviously been buried in the silt deposited by the rivers on their way to the ocean.

In this connection, our geologist found that the Golden Gate was formerly the gorge of a river and that the bay over which the bridge is built was formerly a valley. During the ages there was a sinking of the Pacific Coast, at least in this region, which caused the ocean to enter the Golden Gate and fill up the valley, making San Francisco Bay. The tooth of this old fellow is now at the Department of Paleontology, University of California, where it is honored as belonging to the first commuter.

Working platforms, 60 by 141 ft in plan on opposite sides of each caisson, were set up on timber piles equipped with from two to four stiff-leg derricks of 21-ton capacity with 100-ft booms and 45-ft mast, operated by 3-drum hoist engines with 150-hp, 440-volt, three-phase, 60-cycle motors. Each platform had two or four turbine pumps, each with a capacity of 1200 gpm, and angle air compressors.

ANCHORAGES

The suspension sector of the San Francisco-Oakland Bay Bridge, that is the West Bay crossing between San Francisco and the Island, has three cable anchorages. On the west side at San Francisco is a gravity anchorage. In the center is a concrete central anchorage to take care of the unbalanced live load between the twin suspension bridges to the east and to the west.

At the east end on the Island are cable-anchorage tunnels. The San Francisco anchorage is a monolithic structure 184.5 ft long by 108 ft, rising 180 ft above the Beale Street level. It is built approximately 900 ft back from the shore of the bay, because only there could we reach rock at a practical elevation because the shore lands of San Francisco are largely fills. After the earthquake, debris was hauled from all parts of the city down to the bay shore and dumped to create new bay-shore land. Thus most of San Francisco's water-front structures are built on piles. This filled land, by the way, presents extreme difficulties to excavators because the fill is a most heterogeneous mass of debris.

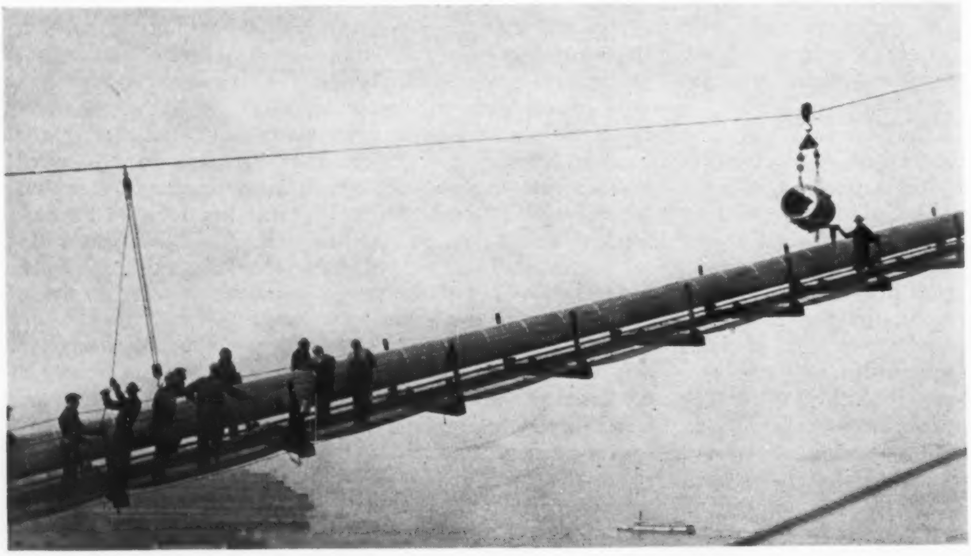
The San Francisco anchorage when completed will contain approximately 68,000 cu yd of concrete and 1200 tons of steel. At the anchorage the steel trusses will end and the concrete viaducts that bring traffic down to the level of the city streets will begin. Some 7000 tons of grillage were embedded in the concrete anchorage. When 33,500 cu yd had been poured, the anchorage block was ready for cable-spinning operations. These cable-spinning operations have now been completed from the San Francisco side to the center anchorage, and the pouring of concrete will be resumed shortly to complete this gravity anchorage.

The center concrete anchorage, which is approximately one mile from San Francisco and also from the Island, has been described in its caisson stage.

This pier required the largest caisson ever constructed, 92 by 197 ft in plan, and resting on bedrock at 220 ft below mean lower low water. This concrete block under water is pierced by 55 15-ft vertical holes formed in the concrete by the tubes of the caisson. Three of these tubes at each corner, making a total of 12 in the block, were filled with concrete seal from bottom to top to provide weight to resist the up-ending force applied by the cables anchored at the top.

The A-frames of the center anchorage, weighing about 410 tons, were hoisted in 14 sections, the largest of which weighed 73 tons.

Above water this center anchorage is a huge, hollow, concrete structure, tapering from 197 ft along the line of the bridge by 92 ft (transverse width) to 78 by 163 ft at the level of the lower deck, an elevation of 235 ft. Above water this anchorage contains two large rooms, the full height of the structure, separated by a transverse diaphragm of concrete running across the center of the material. The longi-



CABLE BAND, WEIGHING FROM 2000 TO 3200 LB, BEING PLACED ON THE SUSPENSION CABLE TO PROVIDE GROOVES FOR SUSPENDER ROPES FROM WHICH WILL BE HUNG THE BRIDGE DECK STRUCTURE

(Suspension cables of this bridge are $28^3/_4$ in. in diameter and contain 17,464 individual wires, each 0.195 in. in diameter.)

tudinal side walls taper from 17 ft thick, and into these are embedded 135-ft steel eyebars which hold down the two A-frames set parallel to the suspension cables, and to which are pinned the eyebars for the attachment of the strands of the cables. A chain of vertical eyebars embedded in the walls of the anchorage is attached to a horizontal steel girder 12 ft long, 170 ft below the A-frame, thus distributing the cable pull throughout the entire anchorage. The A-frame, with eyebars at the top, will be embedded in concrete and hooded with a plate-steel cowl in the completed structure.

THE TUNNEL

The vehicular tunnel through the Island, with a bore 140 ft long involved an excavation approximately 60 ft high by 80 ft wide, and inside dimensions of 56 ft high by 76 ft wide. This tunnel is double-decked, the upper deck being set on a shoulder of the concrete side walls which have a minimum thickness of 4 ft, and the crown of the tunnel has a specified minimum thickness of 3 ft.

The size of this tunnel and shattered rock required a rather unusual method of operation. Three tunnels were bored through the Island at the start of operations. These pioneer drifts were 12 by 14 ft in cross section, one at either lower side wall and one at the crown. During the blasting, with average shots consisting of 25 holes 10 ft deep and 100 lb of 40 per cent powder, carried these pioneer headings through the Island.

The two side tunnels were broken out to the full height of the side wall about 40 ft high for the length of the tunnel, which is 540 ft. Concrete forms were set up, reinforcing rods placed, and the concrete side walls were poured up to the spring line. At the same time side drifts were bored down from the crown heading to the side drifts. Sixteen-inch steel H-beam ribs, set on 3-ft centers, were erected on the shoulders of the side wall to support the roof of the tunnel. The result was a horseshoe-shaped excavation, leaving a core of rock within the tunnel untouched.

SUPERSTRUCTURE

ALTERNATIVE DESIGNS

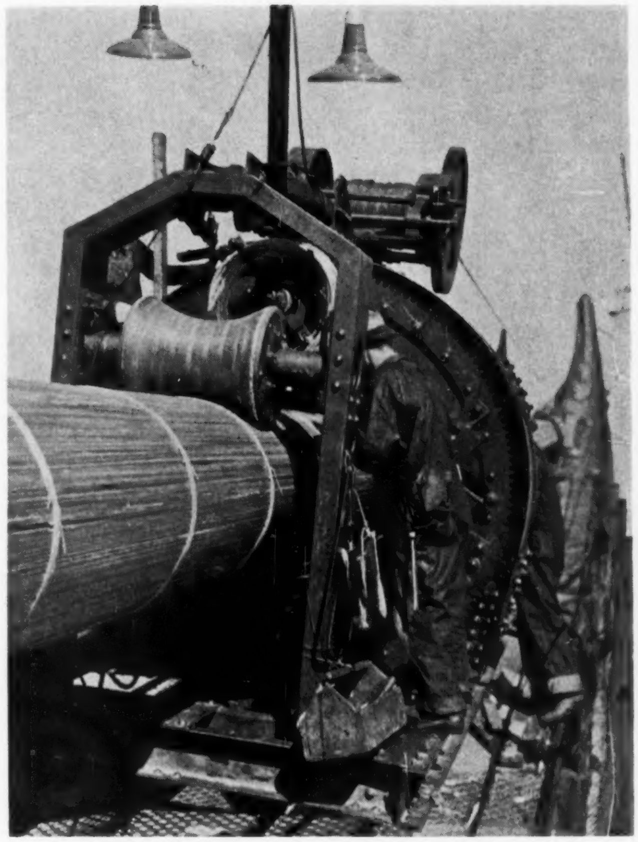
The general natural conditions existing at the various sites available for a bridge across San Francisco Bay between San Francisco and Oakland offered to the bridge engineer the greatest range in design and engineering judgment yet presented in major structures.

The West Bay crossing, with 9000 ft of major navigable water, was too great a distance normally to expect to cross with a single suspension span, and because of this fact a new problem in major suspension-bridge design was encountered; i.e., the designing of two or more major suspension spans end to end. Under the permit no more than four piers could be placed in the channel. The principal suspension-bridge layouts considered will be briefly noted:

(1) A twin-span suspension bridge with 2900-ft main spans and two 1090-ft shoreside spans. At the center, unloaded side spans crossed over a heavy concrete-and-steel arch of 930-ft span between abutment piers. The thrust of the arch was utilized to oppose partially the horizontal pull of the cables.

This layout had the great advantage of two long spans fo navigation and it was rigid when compared with other possible suspension layouts. It had a considerable disadvantage at the center because of the restricted clearance under the arch and the attendant hazard at that point to navigation. The cost was considerably more than the cantilever.

(2) One of the first suspension-span layouts to be studied



RADIAL JACK, MECHANICALLY OPERATED BY AIR MOTORS, USED TO SQUEEZE THE 37 STRANDS OF THE SUSPENSION CABLES INTO ROUND, COMPACT SHAPE

(These compacting machines embodied six mechanically operated screw jacks, exerting 75-ton pressure on all sides of the cable. A wire-wrapping machine binds the cable every three feet to hold it in form pending the application of the one-ton cable bands and final wrapping after the decks have been suspended from the cables.)

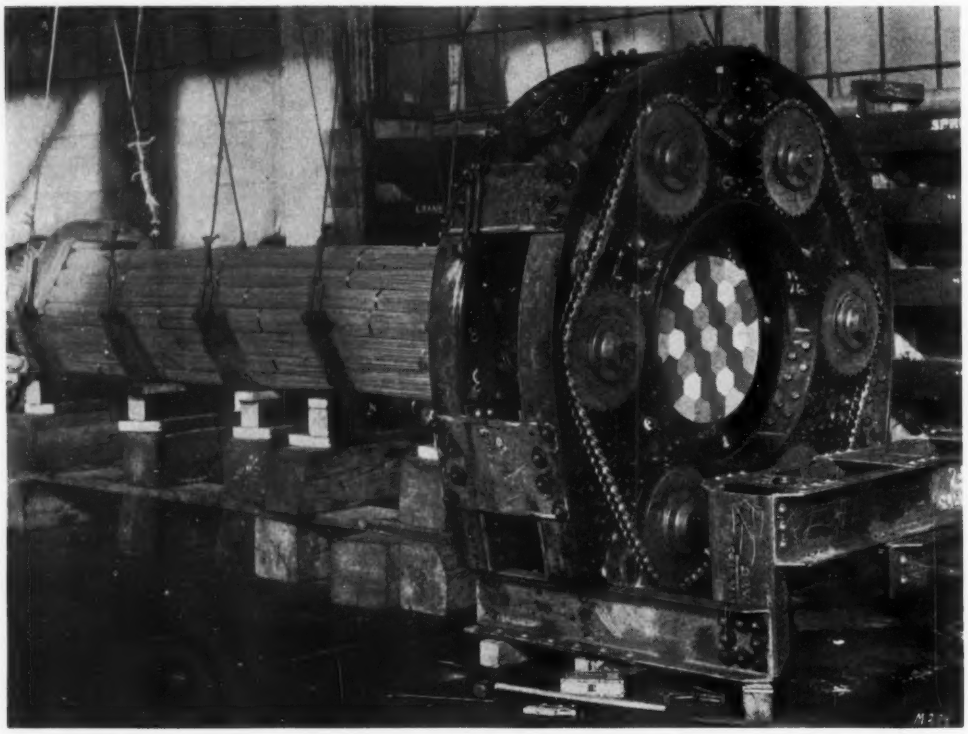
was one similar in all respects to the plan finally adopted, except that final foundation investigations necessitated the setting back of the San Francisco anchorage and the addition of an unloaded backstay.

The layout consists essentially of two simple suspension bridges end to end with a central live-load anchor pier. In the final plan adopted the layout was changed to two 2310-ft spans, four 1160-ft side spans, and an unloaded backstay in San Francisco of about 900 ft.

Careful studies of this layout in the earlier designs and later in detailed design, in the San Francisco office, conclusively proved this plan to be the most feasible. Its cost was about the same as that of the cantilever. The pier locations were at the highest average rock level.

The structure was sufficiently rigid in character, though the long backstay increased deflections somewhat over the original plans contemplated. The span lengths were such that great width was not required and a double-deck cross section could be economically used. The problem of erection was less hazardous than in the cantilever.

(3) Continuous suspension spans of two, three, and four spans, with and without tower ties, were investigated. These layouts without tower ties were so flexible that their use was impracticable. When tower ties were introduced into these major spans so many unknown stresses were set up that it was



SHOP VIEW OF CABLE SQUEEZER SHOWN IN OPERATION IN PREVIOUS ILLUSTRATION

(The chain drive brings six 75-ton jacks to bear on the cable from all sides. This compacting machine travels the full length of the cable, squeezing it as it goes. After it is compacted, the cable is treated with red-lead paste and wrapped spirally.)

considered highly presumptuous to attempt their calculation, particularly in a major structure such as this. The question of erection involved principles and practices unknown to date in suspension-bridge construction.

(4) The design of a single simple suspension span was made. In this design a central span of well over 4000 ft and side spans of 2000 ft or more were required. Because of the long side spans great flexibility was encountered. Further difficulty was run into at the San Francisco anchorage and piers. The cost was higher than any other workable plan.

On the east channel, where a 1400-ft span with 185-ft vertical clearance was required, a further problem in design was presented. From a purely esthetic point of view it would have been desirable to use either a suspension span or an arch span. The foundation conditions at the offshore end made either the arch or suspension type difficult and costly because of the great depth to rock (330 ft).

Self-anchored suspension and cross-tied arch spans were designed but both proved uneconomical, if not impossible, from an erection standpoint. As a result, the cantilever type was adopted.

RESEARCH

Models. Because of the numerous types of suspension spans being studied, stress models were made of two of the apparently best types of suspension bridges. These models were made to a $^1/_{100}$ scale in structural similitude. They were such that exact scale loads could be applied in a manner similar to those which will actually be applied to the bridge. The exact stress and deflections for any given load distribution could be read directly from the model.

The effect of wind on the structure was obtained by applying unit horizontal loads.

The effects of horizontal loads, due to earthquakes, could be generally observed by applying certain lateral movements. The two general types of spans modeled were the simple suspension as noted under plan 2 and the two-span continuous suspension without tower ties. The stresses and deflections obtained from the models check with remarkable closeness those obtained mathematically.

Rivet Tests. The shop-fabrication and field connections in this structure require rivets up to $1^1/_4$ in. in diameter with grips up to more than 7 in. A considerable quantity of these rivets are of manganese steel.

Numerous cutouts of these rivets, soon after driving in the field started, gave considerable concern to construction engineers. Cutout rivets were accurately calipered and a large percentage were found to be not filling the holes.

An investigation was started. The contractor made several test blocks with from 4 to 6 in. of metal. Rivets were driven, as in the normal practice, with standard rivet guns and air buckers. The first block driven in the normal manner, as the men had been doing in the field, was sawed through the rivets. It was found that practically none of the 6-in. grip rivets were properly filling the holes. In fact, a large percentage still lacked the full $^1/_{16}$-in. clearance given for filling holes. After consulting authorities, it was found that little was known on the subject. Apparently no great concern has been given in past practice by engineers on heavy steel bridges.

The results of our first investigation and subsequent results of the first test block clearly indicated that only the friction between plates could be dependend upon to resist tension until a considerable slip occurred, and that after slip occurred the percentage of rivets taking stress would be unknown but without question only a part of those in the joint.

Further experimentation was done. Several more test blocks were driven with different types and sizes of hammers and bucker-up tools fitted with snaps of different shapes. Different degrees of heating were tried and different types of rivets, including various degrees and stages of tapering. Straight-shank rivets with cold clearance cut to $^1/_{32}$ in. were tried. Carbon and manganese rivets of comparable size and shape of head were driven in the same blocks under various heats.

Riveters were given opportunity to make suggestions as to various methods of procedure.

As a result of these cooperative experiments a combination of all the advantageous elements was written into a set of rules and riveters were schooled accordingly. A brief report was written on the tests and is in the files of this department.

It is believed that with proper equipment and proper school-

ing of riveters, in the operation of driving rivets, large long-grip rivets can be made to fill holes with a cold clearance of $^1/_{16}$ in., at least a large percentage of them. If, however, the ordinary riveter is permitted to drive large long-grip rivets with ordinary equipment, dire results are likely to result, particularly in large tension joints.

Riveted-Joint Tests. Engineers have always been confronted by a lack of knowledge as to the action of rivets and splice-plate metal in the design of large riveted joints on pin-plate connections. It was believed that a project of this size owed some contribution to engineers along this line of knowledge. As a result, a considerable amount of money has been made available for the test of large riveted joints.

Tests are now being carried on at both the University of California and the University of Illinois under the direction of this department, and it is hoped that some real constructive knowledge of this unknown engineering subject will be found in the final report on these tests.

ERECTION

EAST BAY TRUSSES—CANTILEVER

The cantilever is composed of two anchor arms 508 ft long and a clear center span of 1400 ft, the cantilever arms being 412 ft and the suspended span 566 ft. A minimum clearance of 192 ft above low water at each end is increased to approximately 200 ft in the center. The depth of the trusses vary from 97 to 192 ft. The total weight of cantilever span with the two supporting bents is approximately 23,000 tons.

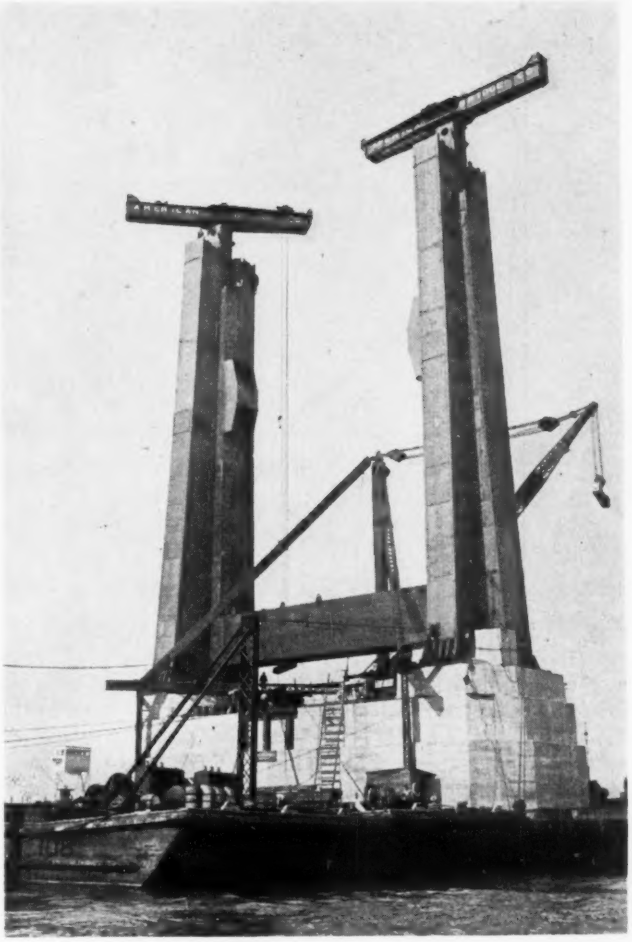
The usual method of erecting the suspended span is to assemble on barges and raise as one unit, but the extreme weight of this span, 35,000 tons, makes this method impracticable, so it will be erected as a cantilever for the entire center span.

WEST BAY SUSPENSION SECTION—TOWER DESIGN AND ERECTION

Structural-steel towers, consisting of two columns joined by diagonal bracing, support the suspension sector of the San Francisco-Oakland Bay Bridge constituting the West Bay crossing. These towers are the first batter-leg towers ever used in a major suspension bridge. Each tower leg inclines inward toward the other, and tapers toward the top. The two outer towers, W-2 and W-6, are 474 ft high from the top of the concrete pier, which has an elevation of 40 ft above water. The two inner towers, W-3 and W-5, on either side of the center anchorage are 45 ft higher than the outer towers, because the bridge truss spans rise to a maximum height of 216 ft above water at the center anchorage.

The roadway of the bridge, which is 58 ft wide from curb to curb on the upper deck, is a 7110-ft vertical curve, 48 ft higher at the center anchorage than at the most easterly and westerly towers. These towers support suspension cables designed for a live load of 4000 lb per lineal foot per cable, and in addition an unbalanced live load in excess of 3000 lb per foot. The average dead load of the suspended structure, including cables, is 20,000 lb per lineal foot. Extreme load conditions therefore result in a longitudinal movement with the bridge, that is, east or west, of 6 ft 6 in. at the top of tower W-2 near the westerly end of the bridge. This extreme deflection is due to the existence of 890 ft unloaded length of cable between the end of the suspension bridge and the San Francisco anchorage.

With such movement necessary, a quite flexible tower was required. The tower designed for this purpose consists of two columns joined by diagonal bracing, and each column has a cruciform section. This cruciform column is divided at the base into 21 cells, separated by $1^1/_8$-in. plate silicon steel. The



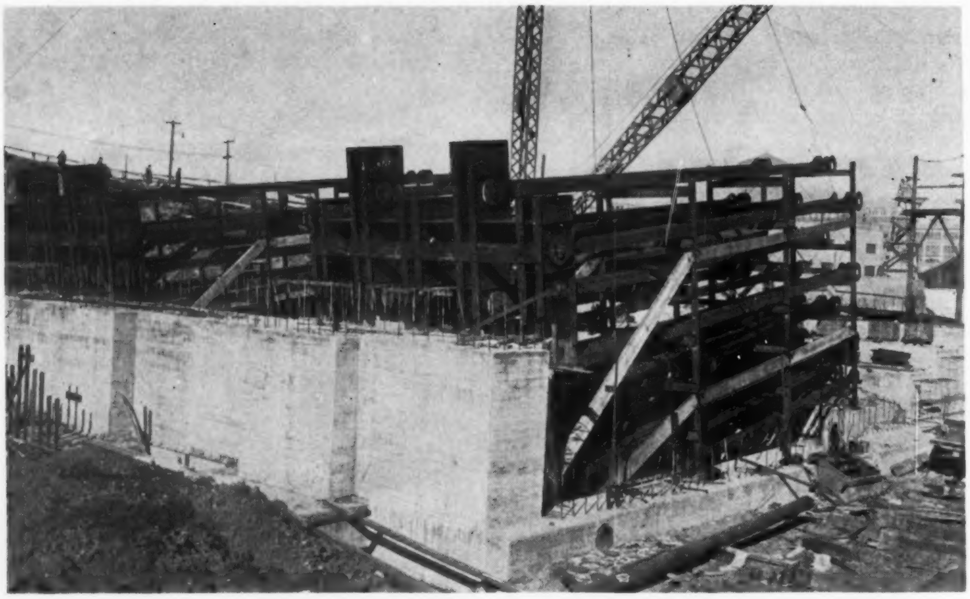
HAMMER-HEAD DERRICKS PROTRUDING FROM TOPS OF BRIDGE TOWERS

(Both legs of the tower are raised to the height of the hammer-head derrick, and the hammer-head itself must now be raised another 60 ft within the tower legs so that it can go on adding height to the tower.)

number of cells is reduced to nine just below the top and to 13 for the greater part of the height of the tower. These cells are fitted with ladders for the painters and riveters, and the center cell, 7 by 8 ft in plan, provided a well in which to set up the 108-ft mast of hammer-head derricks which accomplished the erection of these towers, in place of the creeper travelers commonly used in bridge-tower erection.

The roadways over the truss spans of the bridge are attached to these towers by means of anchor arms, allowing for the necessary play. A rectangular slot in the lower roadway strut in each tower provided for a wind-resistance connection to the span. These towers were fabricated and erected by the American Bridge Company as subcontractors to Columbia Steel Company, general contractor for the entire superstructure of the San Francisco-Oakland Bay Bridge.

Silicon steel was used for the legs of the towers. Carbon steel was utilized for the diagonal bracing and other details of the tower. Stresses in the tower were calculated for transverse loading, from a ninety-mile-an-hour wind, and from earthquake. In a suspension bridge, transverse stresses from earthquakes are comparatively small. A shock of one-tenth acceleration of gravity in both longitudinal and transverse directions also were calculated. In the latter case, inertia of the suspended structure would resist a considerable force exerted



EYEBARS IN PLACE AT SAN FRANCISCO ANCHORAGE FOR NORTH AND SOUTH CABLES

at the truss level. In the tower design, the vertical reactions from the cables and stiffening trusses and the horizontal cable movements at the top of the towers were carefully calculated. Sections of the tower were assumed. The horizontal force was then found at the top of the tower, as would be necessary in combination with other forces, to deflect the tower an amount equal to the cable movement.

With this force known, stresses were arrived at, and the tower sections designed accordingly. This resulted in placing material in the most efficient location to provide for the stresses calculated. In the case of tower W-2, reinforcing plates were added between the upper-deck strut and the top of the tower, where maximum bending stresses were more severe than at the other towers. Additional plates were riveted on the inside of the cells at the points where the extra strength was required.

Erection of these towers was accomplished by means of a hammer-head derrick. After 50 ft of tower column had been erected by an auxiliary derrick, down the center well of each column was set a hammer-head derrick mast, 108 ft long and approximately 5 ft square. In this mast was a smaller revolving mast, extending only halfway down the main mast, and resting on ring bearings with high-pressure lubrication.

This hammer-head, cross-arm derrick had a lifting capacity of 80 tons on a 16-ft radius, with a concrete counterweight attached to the rear end of the hammer-head.

Suspending the bridge from the cables in the twin suspension bridges of the West Bay crossing is just now starting on the west bridge. The spinning of the cables is now under way on the east bridge. In order to equalize the load on the cables we shall suspend the first units of the bridge decks in the middle of the sag of the main 2310-ft span. This will be followed by the erection of units at the outer ends of the side spans working inward toward the towers. However, all the erection units of the main span will have been suspended from the cables before all of the westerly side span has been erected. We shall leave the major length of the cables for the westerly side span unloaded until after the trusses have been suspended from the other twin suspension bridge on the other side of the center anchorage, so that at no time will the unbalanced load on the common center anchorage for the two suspension bridges exceed 6200 tons per cable.

CABLES

The specifications and plans governing the manufacture and placing of the wire cables and their appurtenances follow closely accepted practice for the construction of suspension bridges.

Bright-wire diameter averaged 0.193 in.; after galvanizing, the diameter averaged 0.196 in. Tests were required to prove a tensile strength of 220,000 lb per sq in. and ability to coil around a $^5/_{16}$-in. rod without a sign of fracture.

SPINNING

The first step in the construction of the main cables of the bridge was to provide a catwalk to serve as a working platform from which all work on the cables, excepting final painting, could be carried on. These walks also carry various parts of the spinning equipment, such as gallows frames to support the hauling rope, live-wire sheaves, and adjusters' platforms.

Each walk, which is about 10 ft wide, is made up of three major parts: (1) The four support ropes, spaced about 3 ft apart laterally; (2) the floor, composed of wooden crossbeams and three sizes of wire mesh; and (3) the so-called storm system used to steady the walk from wind and construction vibration.

Cable spinning followed the usual procedure with some improvements in electric switches for the stopping of the spinning wheel by workmen all along the catwalk. The automatic brakes on reels are, I believe, new.

COMPACTING AND WRAPPING

In order to transform the 37 individual strands having a hexagonal cross section into a single unit having a cylindrical shape, a machine was developed which would press the cable strands together, filling the voids between them.

In general this machine consists of a carriage supported on wooden rollers planed to fit the contour of the cable and a circular frame or yoke to hold the six screw jacks, each one capable of exerting a force of 75 tons in a direction radial to the cable.

After practically the entire dead load has been placed on the bridge the cable will be protected from the elements by wrapping with No. 9 galvanized wire. This wire will be wound around the cables as tightly as possible continuously between the cable bands. Before it is placed the cable will be painted with a heavy coat of red-lead paste so that when the wire is pulled tight the paste will squeeze up through the interstices between adjacent wraps and effectively seal them.

The machine which will be used for this operation has not been entirely designed as yet but will be of the type known as the Robinson. This type has three bobbins of wire so fixed as to revolve about the cable, placing the wire in a continuous spiral between bands. In order to make the turns of the spiral tight one against the other the machine will be pushed forward as it revolves by means of a foot working against the preceding wraps.

SAFETY MEASURES

It is important to realize that heavy industry is always a dangerous business and while we are building improvements to benefit the human race, we are also concerned with the welfare of the human beings who are performing the labor that makes the improvements possible. On such heavy construction there is an expectancy of one death per million dollars expended in actual construction. Thus far we have spent approximately $35,000,000 and we are thankful that our loss of life has been but 16 men.

Our bridge provided unusual hazards and our insurance rates were high. We have 27 piers entirely surrounded by deep water. We have $4^1/_2$ miles of structural steel, some of it more than 200 ft high and all of it above dangerous water.

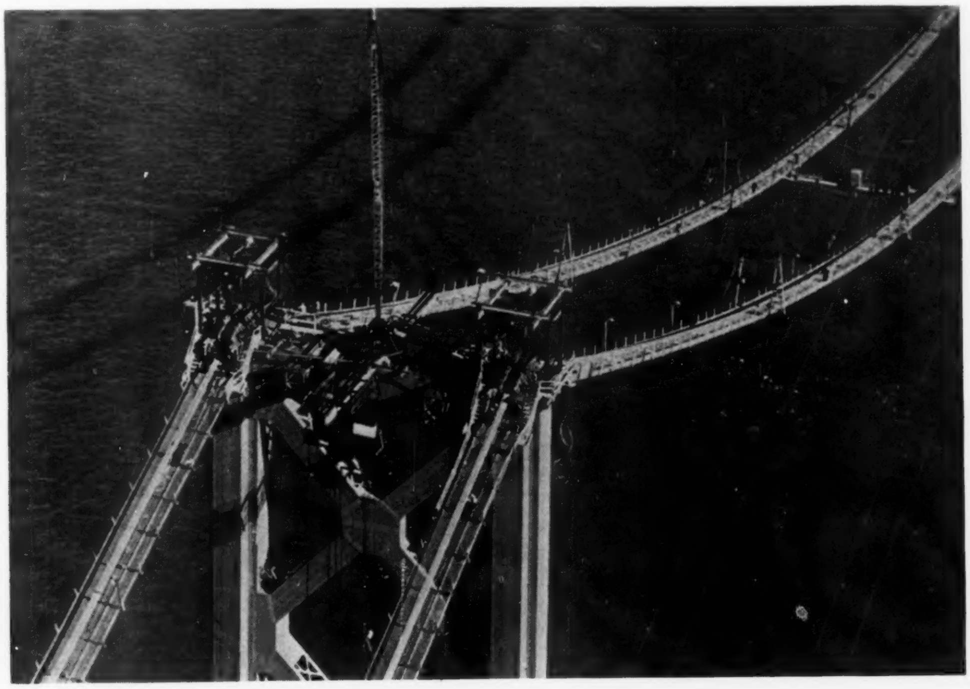
The cable-spinning portion of the job was really the least dangerous and the insurance rate per hundred dollars per man was $6.60, whereas on the structural-steel erection in the truss spans the rate was $22.18 per hundred.

To meet the perils of this job we had a veritable safety campaign, and let me say that I have found on the part of engineers and contractors a sort of reluctance to utilize safety measures. This reluctance, or this resistance to safety appliances, extends from the bottom man to the top man. The lowliest member of a bridge crew despises safety jackets, safety hats, and safety shoes, and has to be required under compulsion to wear them. In this connection we provided the compulsion. Men were required on penalty of being immediately discharged to wear a sort of fabric and bakelite skull-protecting hat somewhat similar to the helmets worn by the soldiers in the late war. Where men were not working too high above water we required kapok vests which had a sort of Queen Anne collar to keep the man upright and floating in the water. Shoes were required to have steel caps over the toes, on the substructure work, to prevent fractured digits. On the catwalks, shoes with a safety tread to prevent slipping were requisite. Contractors were required to build stairs, more easy to ascend than those in their own homes, out on caissons and on working platforms. Hand railings were firm and well constructed. By these means we have succeeded in holding the accident frequency rate down to 355 reported injuries per million of man-hours, and of these injuries few involved loss of time, the great majority being the type of injury which is fixed up by some iodine on the job.

CONCLUSION

I have now completed a picture of the San Francisco-Oakland Bay Bridge from a distance and close-up. From a standpoint of the cost, the depth of the piers, the huge quantities of materials—1,000,000 cu yd of concrete, 200,000 tons of steel, 30,000,000 board feet of lumber, and 200,000 gal of lead and aluminium paints—it is without doubt the greatest single bridge project ever undertaken; but with all the bigness of this project, its builders still bow in all humility to the engineers who conceived and executed the grand old Brooklyn Bridge more than fifty years ago when every stage of design was blazing a new trail into an unknown wilderness.

Today, with steel available with an ultimate tensile strength one and four-tenths times the strength of the wire available to the Brooklyn Bridge, we are treading the well-beaten path of the pioneer bridge builder. We, therefore, dedicate our bridge to those pioneers of suspension- and cantilever-bridge construction who went before us.



LOOKING DOWN ON ONE OF THE TOWERS

(The aerial photographer swooped close to the top of the 519-ft suspension tower of the bridge to get a close-up of the men on the catwalks and the cable saddles on the top of the tower. The tower is of structural steel plates, $1^1/_8$ in. thick. It contains more than 6000 tons of steel and rests upon a concrete pier which extends 180 ft below water. The catwalks in the picture are steel-wire-mesh foot bridges, 10 ft wide, set 66 ft apart at centers. Portions of the cable wires already spun can be seen above the catwalks and over the cable saddles on the tops of the towers.)

MACHINE TOOLS *and the* ECONOMIC SITUATION

By HERMAN H. LIND

NATIONAL MACHINE TOOL BUILDERS' ASSOCIATION

IN THE discussion of so broad a subject as machine tools and the economic situation, even in a short paper it is necessary to review briefly the background of the machine-tool industry in America and to take note of the youthfulness of the Machine Age, as we know it now, and its effect on the lives and living of our people.

The energy, perseverance, and ingenuity that settled the New America and established a new and independent government were responsible for pioneering novel ways and methods of doing things, and for substituting mechanical power for man and animal power. The same initiative and resourceful spirit that opened the wilderness could also put to practical use the means to reduce human drudgery and to increase for man the comforts of life. It was only natural then that power-driven machines, which had but recently been invented and built in England, should suggest to New Englanders improvements and adaptations that led to new uses and entirely new developments.

The frontier was constantly driven back, thus taking people farther and farther from settled and established habitations. The settlement of the new frontiers was arduous work. Men toiled from sunrise to sunset and constantly demanded hand tools, greater comforts for living as enjoyed in the settled areas, and better transportation. The eastern seaboard, particularly New England, strove to provide these wants, and it was evident that if a few simple tools helped to satisfy the barest needs of the frontier, more and better tools would effect added conveniences and greater ease of living.

It was in this atmosphere that the building of machines for cutting metal began to emerge as an industry about a century ago. The character of the mechanical pioneers responsible for the development of this industry was such that they have left an indelible impression that is now, and always will be, with us. They were mechanics of the inventive type imbued with the New World theory of personal industry, ingenuity without bounds, integrity, thrift, and above all, courage and fortitude. The satisfaction that comes with the solution of a difficult mechanical problem was the chief reward in many, many instances.

The intermittent power from the water wheel gave impetus to the development and expanding use of steam power, but this advancement could not go forward until machines were produced to build the steam engines and boilers that in turn were used to run the machines. In this simple beginning the interdependence of machines of various types was demonstrated. The principle of the steam engine was comprehended by Watt many years before it could be built as a serviceable power unit, because of the lack of tools to bore the cylinder. Likewise, interchangeability of parts, which is the basic principle of mass production, could only come about with the development of machines that made possible accurate reproduction in minute details.

Contributed by the Machine Shop Practice Division and presented at the Semi-Annual Meeting, Cincinnati, Ohio, June 19–21, 1935, of The American Society of Mechanical Engineers.

The building of machines for the various purposes required a particularly skilled type of mechanic; an extension of the type that gave the industry its start. These men, trained in the art of machine-tool building, later were sought by the users of the tools for the manufacture of specialized products. In this way the machine-tool industry has been the training ground for workmen and executives who in their respective places have spread to every other industry the knowledge and use of the fundamental principles under which they developed.

The transfer of men trained in the art of machine-tool building to other industries using the machines has had the interesting effect of bringing back to the machine-tool industry demands for new developments and suggestions for better high-production tools, and for tools to manufacture new and improved products. Thus this industry becomes a "service industry" for all other mechanical industries.

The machine tool has a long life. It scarcely ever wears out but is finally replaced because a new improved tool makes the operation of the old one uneconomic. The average economic life of machine tools in general is accepted as being about ten years, while the actual useful life is more nearly twenty to thirty years. Consequently, the value of machines in use is at least twenty-five times the volume of sales or replacements for a typical year.

The protracted life of this equipment is responsible for the fact that the total investment in the machine-tool industry is far below, and out of all proportion to, the relative importance of the industry as compared to other large industries. Practically every company had an extremely small beginning and has financed itself through its own earnings and savings. In money investment, therefore, it does not loom high, but the industries whose outputs are solely dependent upon it comprise those engaged in the production of the goods that contribute to a higher material standard of living and on which millions of workmen are dependent for employment. In this respect it may be said that the small group of men employed in building machine tools is multiplied manyfold in the operations of the machines, to say nothing of the chain of men employed in selling and servicing the products made from the tools.

The machine tool, both directly and by means of other machinery produced by it, has been primarily responsible for reshaping the lives of the people and their means of livelihood. For instance, in 1850, when the population of the United States numbered 23 million people, farm machinery and tools were valued at 151 million dollars. In 1930, with a population of $118^{1}/_{2}$ millions, the value of farm machinery and tools was approximately $3^{1}/_{2}$ billions.[1] In other words, the population multiplied five times while the value of farm equipment multiplied twenty-one times. It has been estimated that during this period the use of machinery multiplied three or four times the productivity per man on the farms and in addition reduced materially the drudgery of much of the farm work.

It is interesting to trace in a general way the men who have

[1] Statistical Abstract of the United States.

changed from agricultural to manufacturing pursuits. As mechanization of the farm began with the introduction of the horse-drawn mower and reaper to replace the scythe and cradle, the production of the ever-increasing number and types of tools lessened the labor requirement in the field and transplanted it to the factory and to the transportation of raw materials and finished products. As new types of farm equipment were developed at lowered costs and their sale extended, the need grew

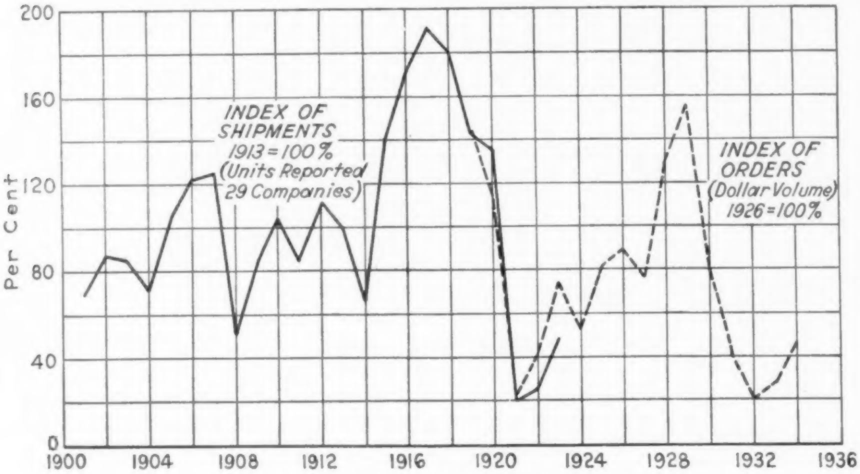


FIG. 1 TREND OF MACHINE-TOOL DEMAND

for basic raw materials from forest and mine. The expansion in the use of these materials in turn demanded better equipment to bring the raw products from the earth and to convert them.

This transfer of men from production by human and animal power to production by mechanical power with tremendously enlarged output leads directly to the release of men from the production of the absolute necessities of life for the manufacture of comforts and luxuries which soon are looked upon as necessities. Examples of this are found in the increased tonnage of ocean passenger vessels, the extension of railroads, automobiles, and good roads, telephones, household appliances, and various other articles that now are so commonplace. Machine tools and the genius of the men who build them are the fountainhead of this great progress in our economic life.

Nevertheless, there are many vicissitudes in the machine-tool industry occasioned by the fact that the machine is so far removed from the individual consumer. When the income of the individual citizen diminishes he can retrench only a little on food, more on clothing, and still more on shelter; but the greatest curtailment of all is in the mechanical products of machinery; and there are many more than enough machine tools to meet the small demand for such products in a period of depression. Therefore, the industry is subject to the widest fluctuations. When the citizen is in the mood for traveling, for buying automobiles, household appliances, and the like, the purveyors to his fancy bend every effort to provide his desires with superior products in greater quantities. The demand on the machine-tool industry in such a period is terrific. However, between the two extremes we find the most erratic irregularities in individual plants and the industry as a whole. The best illustration of this is the fact that in the month of March, 1933, the orders for machine tools amounted to approximately 4 per cent of the orders placed in March, 1929.

In periods of low production the skilled designers, engineers, and mechanics of the machine-tool industry are kept at work on improvements in machines that time does not permit when work is being done under high pressure to meet delivery demands. When the demand for the products of machine tools is great the prices of the products are such that economies of new and better machines are not necessary. On the other hand, when business is low those who utilize the machines do not want to spend money. Unfortunately, manufacturers generally have not yet reached the point of putting their depreciation charges aside in cash. Too frequently depreciation and obsolescence reserves have been used in the payment of dividends that constitute, in fact, distribution of capital.

Those manufacturers who are keeping their machinery modern are producing at costs that will force the users of obsolete equipment to modernize. It is estimated that more than 75 per cent of the machine tools used in America today are more than ten years old. The advance in machine tools in the meantime has been such that it is evident there is a large demand ahead.

Generally speaking, the demand for machine tools is actuated by the following motives: First, the natural growth in volume of business necessitates increased output; second, equipment is essential for the production of new goods; third, obsolete machines must be replaced. (See Fig. 1.)

The first tendency is illustrated by the

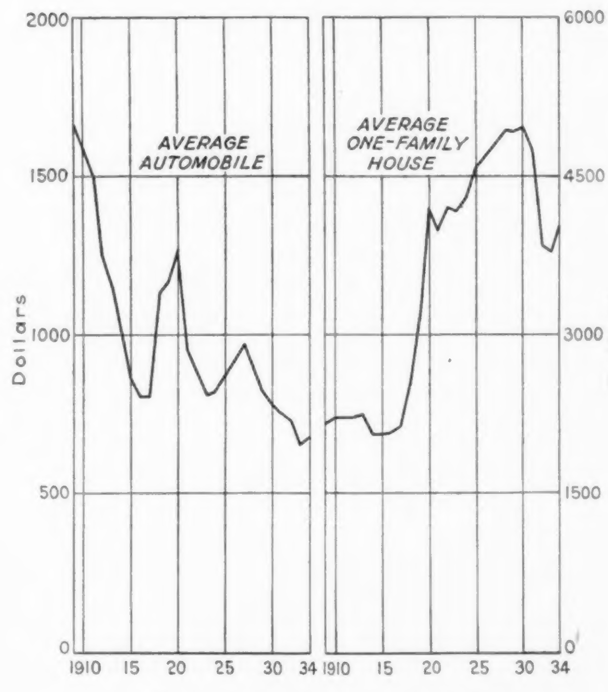


FIG. 2 COSTS OF HOUSES AND AUTOMOBILES

slowly rising trend of machine-tool production from 1901 to 1917 as illustrated by reports of shipments of 29 companies and again by the industry's index of orders as shown in Fig. 1 for the years 1921 to 1929. The second motive for increased demand is illustrated by the sharp rise in sales of machine tools in 1906 and 1907 when the manufacture of automobiles began to reach what then seemed important proportions. Replacement of obsolete machines goes on uninterruptedly during all periods of general activity. Such replacement is

being made on a small scale at present, and we anticipate a more general wave just ahead.

There is good reason for this expectation. There are many very old and inefficient machine tools now in operation. Many manufacturers who use machine tools are notoriously slow to discard the old and install the new. The necessity for low-cost production is paramount. Buyers of the products of machinery are extremely price-conscious and they will continue to be so. A relatively small increase in the price of things which users want will freeze sales, and by the same token a lower price will increase sales and enlarge the range of people who will buy. It is in this effort for ever lower costs that the machine-tool industry can take just pride in what it has contributed to the higher standard of living in making it possible for the people of this country to enjoy 26 million automobiles, 18 million telephones, an untold number of radios, 6 million mechanical refrigerators, and many other similar comforts and pleasures.

A rather significant contrast can be noted between the mechanized industries and the unmechanized building industry. Heretofore, the building industry has been given credit quite generally for leading the way out of depressions. This is only natural because in times of adversity a man begins to think of a home for his declining years, and he combines his savings and his credit to acquire this security. However, the building industry has not taken the lead this time, largely because of the relative difference in the cost of houses as compared to products of highly mechanized industries. Col. Leonard Ayres prepared a chart, Fig. 2, comparing the relative cost of production of automobiles and buildings. The current development of the factory-built steel house is given its opportunity in the relative disproportion of costs of buildings as compared to the prices of other products.

There are those among us who decry the machine as the main contributor to unemployment, some who would even go so far as to limit the use of the machine and new processes and machine methods—in fact, the whole Mechanical Age. I have wondered where these people would have discontinued the use of the machine. Would they have stopped it with the first few slow-moving steamships? Would they have checked it when the railroads displaced the first horses? Would they have hindered its use when the tractors first entered the fields, or at what later stage would they have stopped its progress? Would they say that only the first few thousand wealthy people or Government officials or legislators should drive automobiles? That only these same groups or similar ones should be supplied with electricity? At what point of relieving human drudgery would they cease, and where would they draw the line against rapid and commodious modes of traveling available to people?

Occasionally, we hear that modern machines make mere automatons of men but these critics forget the interminable grind of work when only hand tools were available. The man who toiled with a shovel certainly had little opportunity to vary his work and less leisure for reflection.

The production of every convenience has its roots in machine tools, and without their constant improvement the products which give the most material enjoyment to our people could not be supplied to a wide range of people at costs within their reach; nor could the continual reduction in hours of work persist, allowing more time for the enjoyment of leisure; nor could so many people benefit from the advantages of more and more cultural education.

The conveniences and comforts that contribute to a higher standard of living for American people have been an inspiration to the more backward countries of the world. As a consequence, a good proportion of the industry's production has been absorbed in the export markets. Russia under her planned-economy program has been a liberal purchaser and user of America's modern machine tools. Even though her political, economic, and social system is diametrically the opposite of ours, Russia recognized from the beginning that if she hoped to raise her country and her people to the level of her more advanced neighbors, the development of the capital-goods industries must come first as a foundation for the satisfaction of all other wants. To attain such a foundation the Russian people are making great sacrifices in the basic requirements of food and clothing with the expectation of future compensations. Other nations likewise are adopting that part of America's industrial system and procedure as rapidly as economic and social conditions will permit.

The machine-tool industry cannot claim credit for all the bounties of America's economic life, but it is fitting to point out that it is the foundation of the Machine Age; that from its tools come those other machines for the elimination of human drudgery; that it is responsible for the reduction of costs which permit more people to enjoy the comforts which fashion a better and happier life; that it has gradually and continuously shortened the working day; that it has made it possible for people to travel swiftly and safely over long distances; that it has furnished highly trained men of sterling character and integrity to other industries everywhere; that it has lightened man's work in the field and factory, and woman's duties in the home; and that it has opened new and easier ways of livelihood for millions.

Ernestine Shepard, N. Y.

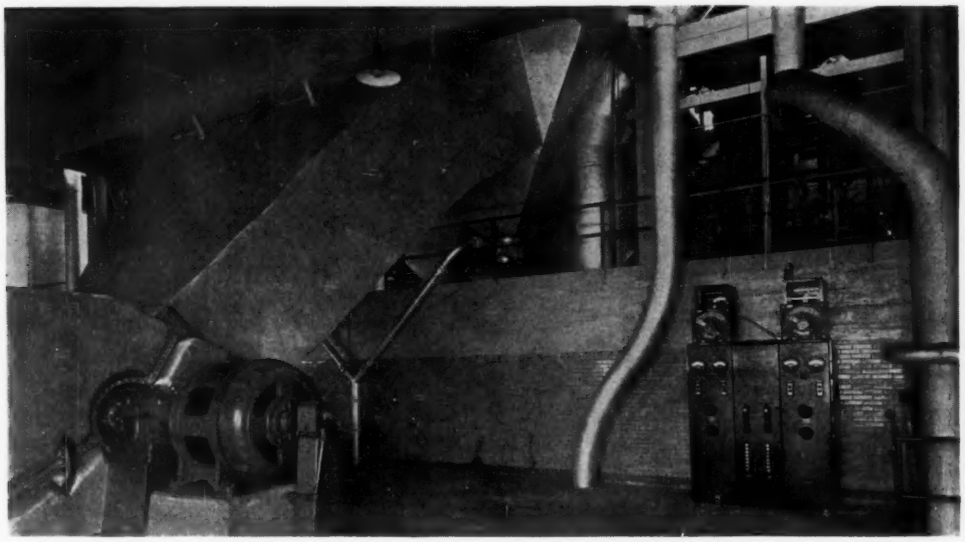


FIG. 1 INDUCED-DRAFT FAN AND Y-INLET FLUE TO PRECIPITATOR

ELECTRICAL PRECIPITATION *for* STOKER-FIRED BOILERS

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AT THE new central-heating station for public buildings at Washington, D. C., electrical precipitators have been installed for final elimination of cinders, ash, and soot from the waste gases from stoker-fired boilers. The use of precipitators for fly-ash elimination on stoker-fired boilers has received comparatively little attention, and it is the purpose of this paper to discuss this problem and the type of precipitator installed in this case in particular.

The problem of cinder and smoke elimination at this plant has been discussed elsewhere[1] in the following terms:

> The plant was to supply steam for heating and other uses to practically all the public and semipublic buildings in the "Triangle District." Considerations as to convenience of steam distribution, availability of property, and proximity of fuel supply made it necessary to locate the plant quite close to the "Triangle District." A large boiler plant was necessary in which great quantities of fuel would be burned and a design was required which would discharge practically no soot or cinders to the atmosphere......
>
> Various considerations ...... dictated a stoker-fired plant, but contributory to that choice was the fact that it was believed that removal of material from the stack gases could more reliably be accomplished with stoker firing than if pulverized fuel were adopted. With stoker firing a static cinder trap may be installed which will remove a considerable proportion of the entrained material under any conditions. This type of equipment is practically useless with pulverized fuel. Some form of hydraulic or electric eliminator is necessary which is subject to possible failure at times, and failure of the system permits all of the fly ash to escape from the stacks. Both gas and oil firing were considered and rejected because of the high price (then present or probable) of these fuels.

To complete the picture it is only necessary to add that whatever was installed had to be adapted to an existing building, for the plant was largely completed at the time when it was decided to install precipitators.

FACTORS GOVERNING PRECIPITATOR SELECTION

Four principal factors had to be considered in designing the precipitator installed in this project. These were as follows:

(1) Government specifications required that whatever was installed should have a satisfactory operating history in a similar application.

(2) Because gases from stoker-fired boilers, especially at the lower ratings, carry a relatively smaller amount of suspended matter than do those from powdered-fuel firing, it was necessary to clean to a low absolute concentration of solids in the exit gases to meet the requirements on percentage of removal.

(3) The suspended material in gases from stoker-fired boilers is a mixture of varying amounts of cinders, ash, and soot or black smoke, each of which behaves in a different way in an electrical precipitator and the combination makes a somewhat more difficult precipitation problem than straight fly-ash elimination.

(4) Space limitations were such that for a compact arrangement a vertical-flow precipitator with the gases entering at the bottom was necessary.

[1] "Cinder and Dust Elimination at the Washington Heating Plant," by F. P. Fairchild and C. F. Dixon, *Combustion*, August, 1935, pp. 13–16.

Contributed by the Fuels Division and presented at the Annual Meeting, New York, N. Y., Dec. 2–6, 1935, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

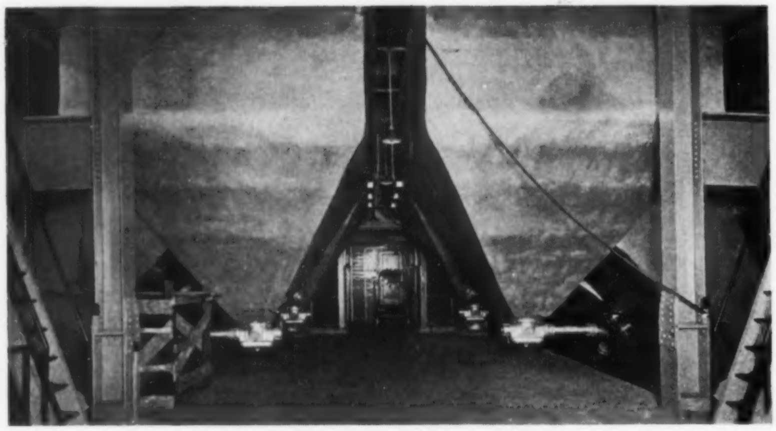

FIG. 2 HOPPER BOTTOMS OF TWO PRECIPITATORS

These considerations led to the selection of a type of electrical precipitator which, while comparatively new in the United States, had been installed for similar purposes at a number of European stations. All of these had satisfactory operating records.

Although the basic operating principle is the same, this type is quite different from the plate precipitators which have been installed on a large number of pulverized-coal-fired boilers in this country and which have been fully described in papers by several authors.[2,3] The principal differences are in the type of collecting electrode and the direction of gas flow. In the concrete-plate precipitator large concrete slabs serve as collecting electrodes. The suspended matter in the gases is precipitated on the surfaces of these and after it has reached a sufficient depth it falls off in the form of large agglomerates or is removed intermittently by a scraping mechanism. In any case the precipitate falls through the main gas stream on its way to the hopper and there is always the possibility that some portion will become resuspended in the cleaned gas.

In the type under discussion the collecting electrodes are hollow steel boxes with openings into the interior where no gas is flowing. The precipitate continuously works its way into the interior through these openings and drops by gravity into the hopper without being in contact with the main gas stream. This feature is the really important consideration in connection with the factors 2, 3, and 4 which governed the selection, and because of this it is possible not only to obtain high removal of suspended material in gases from stoker-fired boilers by electrical precipitation, but also to do it in a vertical-flow precipitator.

ARRANGEMENT OF PRECIPITATORS

At Washington there are six boilers grouped in pairs. The government specifications called for an initial installation of precipitators for two boilers and stipulated that performance in accordance with the required guarantees was to be demonstrated before the other four would be equipped. Accordingly, the initial installation consisted of an individual precipitator for each of two boilers, located above the coal conveyor in the upper portion of the boilerhouse.

The shell of each precipitator is divided into two parallel units by a common dividing wall. It is of steel-plate construction, self-supporting, and carried directly on the steel structure of the building. Since there was insufficient headroom between the top of the coal conveyor and the building roof, the upper portion of the shell extends through the roof. The shells are hoppered, there being a separate hopper for each unit.

The gases to be cleaned flow to the precipitator from the induced-draft fan through a flue which ties into each of the two hoppers through a Y-connection. They rise vertically through the precipitator and discharge through short breechings and a low stack carried directly on the top of the precipitator shell. Neither the stack nor the upper portion of the precipitator shell is visible from the street for they are located inside a stack ornament which is common to a pair of precipitators.

Fig. 1 shows the induced-draft fan and the Y-inlet flue, and Fig. 2 another view of the hoppers and the portion of the shell below the boilerhouse roof. In Fig. 3 is shown the portion of the shell above the roof up to the outlet breechings, and these, together with the common stack for the two units of an individual precipitator, are shown in Fig. 4. The stack ornament is also shown in the left background of Fig. 4.

DESCRIPTION OF PRECIPITATORS

Each precipitator unit is divided into 15 vertical gas ducts formed by hanging 16 collecting-electrode assemblies from structural members in the upper portion of the shell. The method of support is shown in the view of a partially plated unit in Fig. 5. These ducts are approximately 10 in. wide by 11 ft 6 in. long and 17 ft high, and have a capacity of approximately 5700 cfm per duct.

Each collecting-electrode assembly consists of six separate hollow sections or "boxes," 17 ft long and with approximate inside dimensions of 2 ft by $1^1/_2$ in. The two outer and the two inner boxes of the assembly are drawn in near the bottom to give the effect of a double hopper to the lower portion. See Fig. 6.

Prior to fabrication, pockets are formed in the two side sheets

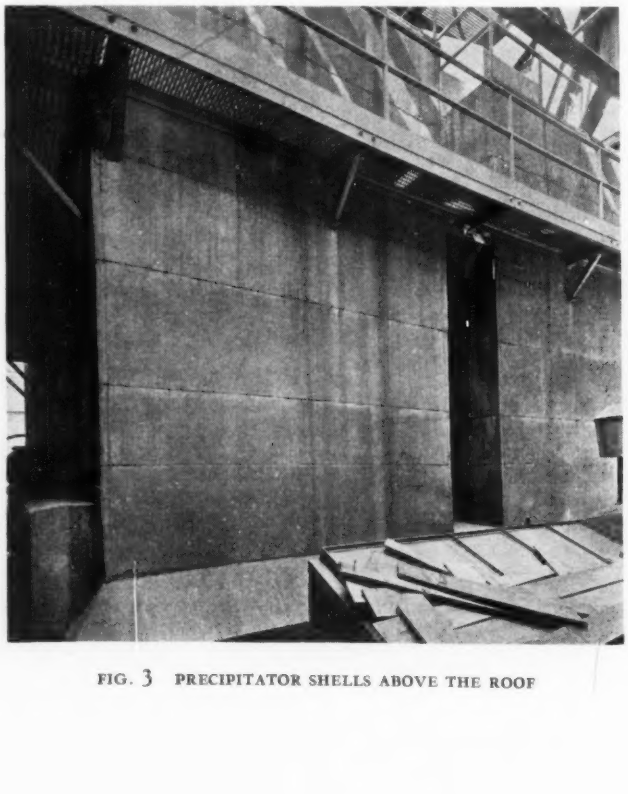

FIG. 3 PRECIPITATOR SHELLS ABOVE THE ROOF

[2] "Catching Pulverized Coal Ash at the Trenton Channel Plant," by H. M. Pier and A. N. Crowder, *Power*, May 31, 1927, pp. 834–837.

[3] "92–98 Per Cent of Dust in Flue Gases Removed at Michigan City Plant," *Power*, March 22, 1932, pp. 425–428.

of each box which provide louver-like openings to the interior. There are 46 horizontal rows of six pockets on each side sheet. They project approximately $^1/_2$ in. and have $^1/_2$ in. by $3^1/_2$ in. openings.

When the suspended matter usually found in gases from stoker-fired boilers is precipitated on any collecting-electrode surface, particles having essentially the same characteristics as fly ash, usually adhere to the surface. The cinder and soot, on the other hand, attach themselves less firmly, and the latter, in the form of agglomerates, has a marked tendency to dance around and, in some cases, to take on another charge and move back into the duct. With this type of electrode either because of electric-wind effects or for some other reason, most of this loose material finds its way through the pockets and into the electrode. The remainder, i.e., that which has adhered, is loosened by continuously rapping the electrodes and falls into the nearest opening. Since no gas flows through the interior of the electrode the dust settles rapidly, and should any of it issue through an opening lower down it is immediately reprecipitated and worked back inside. It is obvious, therefore, that there is little opportunity for material that has once been precipitated to get back into the cleaned gas.

The rapping is accomplished by means of a mechanism which raps each electrode assembly once every three minutes. This mechanism, which is common to both units of one precipitator, is mounted on the outside of the shell at the elevation of the lower ends of the electrode assemblies. See Fig. 7. It consists of a number of cams on a common shaft which is rotated at $^1/_3$ rpm by means of a motor through a 1000 to 1 speed reducer and sprocket chain. These cams actuate their respective horizontal-plunger units, which consist of a helical compression spring and a plunger which enters the precipitator through a stuffing box and which is yoked to the lower ends of two adjacent electrode assemblies. In Fig. 5 it may be noted that the individual boxes of a collecting-electrode assembly are attached to the top supporting members by a single pin. This method of support permits the plunger to move the lower end of the plate assembly in the plane of the plate through a distance corresponding to the rise on the cam. When the cam is released the compressed spring pulls the assembly back against an anvil which transmits to all portions of each box a jar sufficient to loosen the adhering dust.

Since the gases enter the precipitator below the bottom of the electrodes, it is necessary to provide means for transporting the dust from the lower end of each box down through the incoming gases and into the main hopper. For this purpose two sets of intermediate hoppers are provided, one arranged above the other and supported independently of the electrode assembly from members attached to the shell as shown in Fig. 8. The lower ends of the boxes extend down into the hoppers comprising the upper group. These in turn discharge into those below, from whence the dust is carried into the main hopper through spouts which extend below the elevation of the gas inlets. The gas passes through the space between these intermediate hoppers on its way into the ducts and the obstruction provided by the hoppers assists in distributing the gas flow uniformly through the ducts without adding noticeably to the back pressure. The effect of the jar produced in rapping the electrodes is transmitted to these intermediate hoppers and prevents them from becoming plugged.

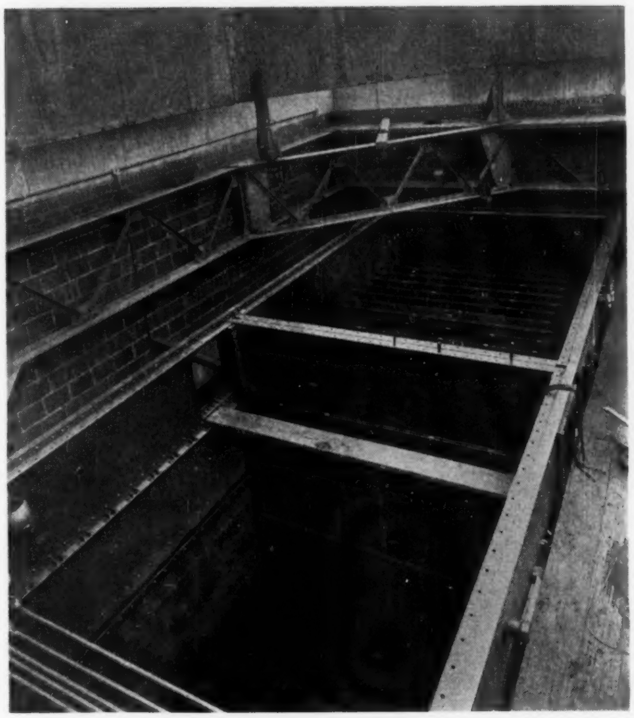

FIG. 5 PRECIPITATOR IN PROCESS OF ASSEMBLY, SHOWING COLLECTING ELECTRODES AND METHOD OF SUPPORT

A vacuum system is provided for withdrawing the dust from the main hoppers and transporting it to the basement of the boilerhouse for disposal.

The discharge-electrode system for each precipitator unit is supported from two sets of insulators in compartments located on the top of the precipitator. There are two such compartments to a unit, one of which is shown in Fig. 9. Hanger rods extend down through bushings and carry the top high-tension frame from which the discharge-electrode wires hang. There are 20 wires per duct, each being weighted at its lower end to hold it taut.

Each precipitator is energized from two electrical sets located in the screened substation which is shown just above the control panels in

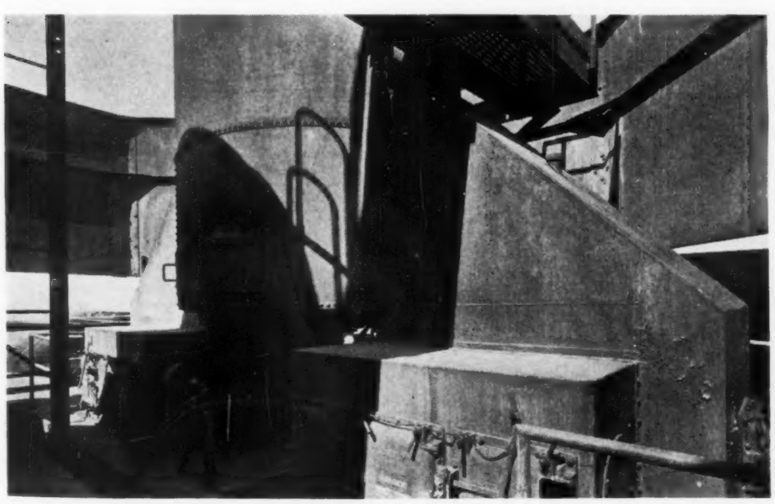

FIG. 4 CONNECTIONS FROM PRECIPITATORS TO STACK

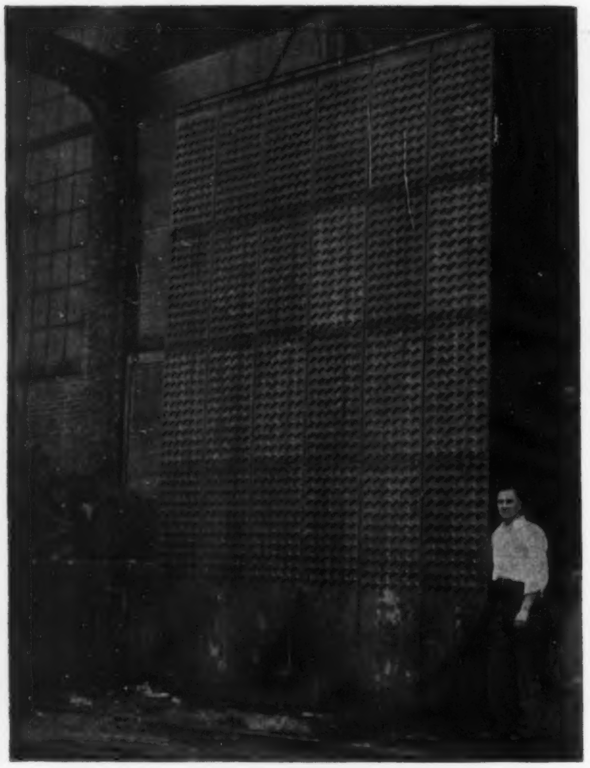

FIG. 6 COLLECTING-ELECTRODE ASSEMBLY

Fig. 1. In normal operation each unit of a precipitator is connected to a separate electrical set, but switching is provided so that the entire precipitator may be energized from either electrical set alone. Connection to the precipitators is by means of high-tension cables which can be seen entering the insulator compartments in Fig. 4.

BUILDER'S TESTS AND OPERATION

The completed installation for two boilers was placed in operation in November, 1934, and in February, 1935, builder's tests were made to establish performance in accordance with guarantees required by the government specifications. These guarantees were to the effect that under normal boiler operating conditions each precipitator should show a removal of at least 90 per cent of the suspended matter in the entering gas when handling any gas volume up to 170,000 cfm at 500 F, and when tested in accordance with the specified test method. This method consisted essentially of determining simultaneously the concentration of suspended matter in the gases entering and leaving the precipitator by filtering metered samples of gas through weighed extraction thimbles which were mounted in holders and inserted directly into the gas streams. Each test was a composite of eight individual inlet and outlet samples which were taken at the stations indicated in Fig. 10. All were drawn for an equal length of time and the velocity of the gas entering the filter nozzles was kept the same as that of the gas stream, which was measured by pitot tubes at the sampling stations. The composite, therefore, is a weighted average for the cross section of the flue. All concentrations were reported in grains per cubic foot of gas at standard conditions.

Total gas volumes passing through the precipitators were calculated because no suitable flue section was available in which to measure it accurately by pitot tubes.

TABLE 1

Test no.	1	2	3	4
Gas volume at main conditions, cfm	74,000	36,000	125,000	160,300
Inlet gas				
Total volume sampled, cu ft[a]	146.55	96.95	161.05	169.95
Total increase in thimble weight, grams	1.796	0.5983	9.1016	5.3128
Total increase in thimble weight, grains	27.71	9.23	140.437	81.976
Dust concentration, grains per cu ft[a]	0.189	0.0952	0.872	0.476
Outlet gas				
Total volume sampled, cu ft	202.0	139.85	189.7	212.3
Total increase in thimble weight, grams	0.1288	0.0569	1.1498	0.343
Total increase in thimble weight, grains	1.987	0.8779	17.741	5.29
Dust concentration, grains per cu ft[a]	0.00983	0.0063	0.0935	0.0249
Efficiency, per cent	94.8	93.3	89.2	94.9

[a] At standard temperature and pressure.

The principal results of these tests and the data from which total gas volumes were calculated are given in Tables 1 and 2, respectively.

During the testing period information was obtained on other operating characteristics, which are summarized as follows:

Pressure drop with a flow of 164,000 cfm was 0.708 in. of water. It should be noted, however, that of the 0.708 in. only 0.395 in. had to be provided by the induced-draft fan; the remaining 0.315 in. was provided by the stack effect of the precipitator itself.

Power consumption per precipitator, including the rectifier

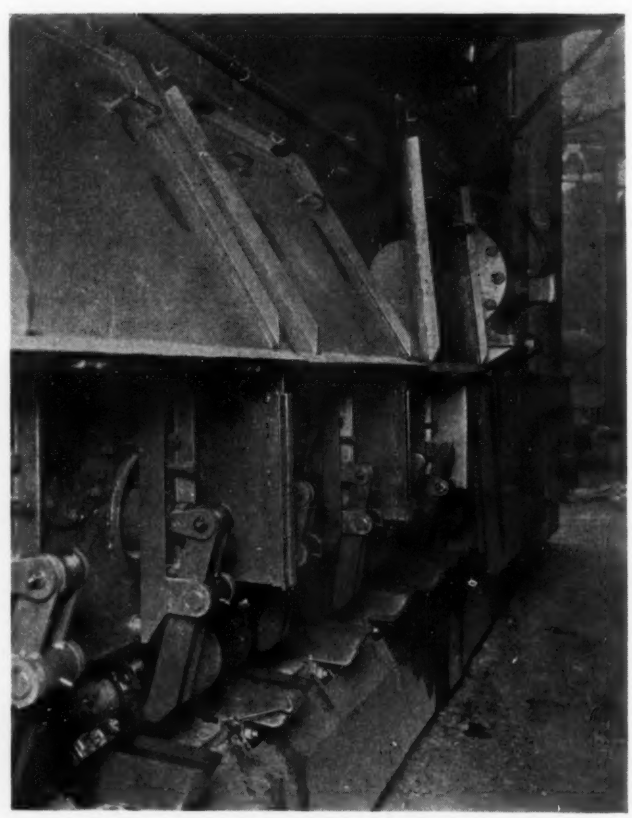

FIG. 7 MECHANISM FOR RAPPING COLLECTING ELECTRODES TO DETACH DUST

TABLE 2

Test no.	1	2	3	4
Average steam flow, lb per hr	148,600	77,000	211,800	198,000
Average steam pressure, lb per sq in. abs	215	215	215	215
Feedwater temp, F	217	217	217	217
Heat in steam, Btu	1199	1199	1199	1199
Heat in feedwater, Btu	185	185	185	185
Coal analysis (approximate)				
Moisture, per cent	2.9	2.9	2.9	2.9
Volatile, per cent	24.8	24.8	24.8	24.8
Fixed carbon, per cent	66.6	66.6	66.6	66.6
Ash, per cent	8.6	8.6	8.6	8.6
Sulphur, per cent	0.8	0.8	0.8	0.8
Btu as fired	13,770	13,770	13,770	13,770
Btu dry	14,180	14,180	14,180	14,180
Total carbon (ult), per cent	76.95	76.95	76.95	76.95
Sulphur (ult), per cent	0.6	0.6	0.6	0.6
Boiler efficiency, per cent	82.0	82.0	78.0	78.0
Dry coal, lb per hr	13,000	6,780	19,140	18,200
Carbon in ash, per cent	10.0	10.0	10.0	10.0
Gas analysis (avg)				
CO_2, per cent	12.9	12.6	11.9	8.5
N_2, per cent	81.2	81.6	81.9	80.6
O_2, per cent	5.9	5.9	6.8	10.9
Lb dry gas per lb dry coal	14.9	15.2	16.1	22.2
Gas temp at precipitator inlet, F	460	380	520	480
Volume dry gas at main conditions, cfm	72,000	34,700	121,000	155,000
Vapor pressure, in. hg	0.75	1.0	1.0	1.0
Volume wet gas at main conditions, cfm	74,000	36,000	125,000	160,300

motors but not including the 2-hp motor driving the rapping mechanism, was 13.7 kw.

The combustible content of the precipitated material varied from 13.8 to 38.4 per cent.

The dust which was being precipitated when the boiler output was 200,000 lb of steam per hour, corresponding to a gas volume of 150,000 cfm, had the following screen analysis: Over 48 mesh 2.65 per cent; through 48 and over 100 mesh 10.45 per cent; through 100 and over 200 mesh 24.3 per cent; through 200 and over 325 mesh 32.6 per cent; and through 325 mesh 30.0 per cent. Samples obtained at lower ratings showed as high as 60 per cent through 325 mesh.

The weights of material precipitated per hour at various steaming rates, calculated from the average inlet and outlet concentrations and gas volumes obtained in the builder's tests, were as follows:

Steam flow, lb per hr	Precipitation, lb per hr
77,000	61
148,600	16
211,800	420
198,000	324

Later, other tests were made, during which the precipitated dust was collected and weighed. At a steaming rate of 200,000 lb per hr 5406 lb and 8731 lb were collected, respectively, in 13 and 24 hr, which correspond to hourly rates of 415 and 366 lb, respectively, or approximately that calculated in the table. It should be noted that these are the amounts which were removed from gases which had already passed through static cinder collectors. The dust weighed 37.5 lb per cu ft.

After eliminating the cause of minor troubles encountered during the initial operating period and traceable largely to difficulties connected with removing the dust from the hoppers, there have been practically no outages on the precipitators. They require no operating attention other than that incidental to rectifier cleaning, lubrication, and hopper dumping.

In general they have met expectations fully and additional precipitators are being installed for the four remaining boilers.

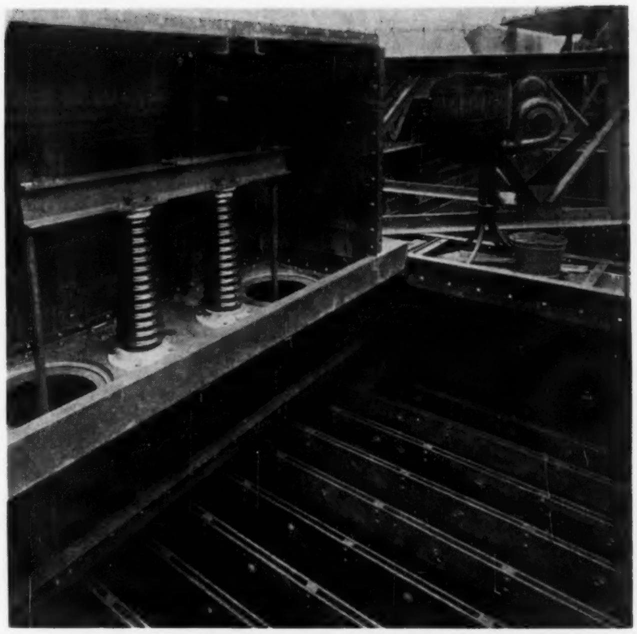

FIG. 9 DISCHARGE-ELECTRODE SUPPORT

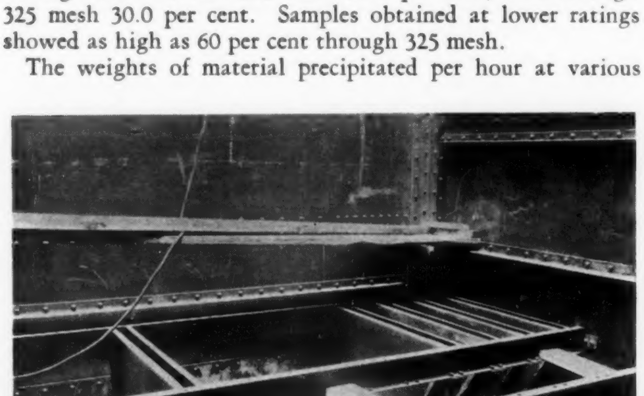

FIG. 8 HOPPERS FOR DISCHARGING DUST FROM COLLECTING ELECTRODES

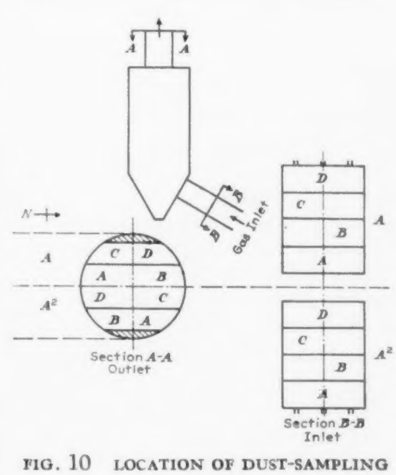

FIG. 10 LOCATION OF DUST-SAMPLING POINTS

FURNACE BOTTOMS *for* TAPPING ASH *in the* MOLTEN STATE

By R. SHELLENBERGER

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THE combustion of pulverized coal in a slag-tap furnace resolves itself into two separate and distinct phases. The first occurs in the lower part of the furnace where turbulence, high furnace temperatures, and ash elimination are required. In the second phase it is required that combustion of the fuel be completed before entering the passes of the boiler proper, also that slagging or "birdnesting" in boiler tubes be minimized if not completely prevented. Furnace design and operation as regards this phase are closely interrelated with those of the boiler. The scope of this paper, therefore, is limited to the slag-tap furnace design and performance regarding the first phase and is based on rather intimate experiences by the author with 80 or more slag-tap furnaces.

Molten slag has been tapped from blast furnaces, cupolas, and various types of metallurgical furnaces since their inception. In metallurgical furnaces the primary object of their operation is to produce metals, and, as in a steam-boiler furnace, the slag is a by-product or necessary evil. The similarity, however, ends here, because metallurgical furnaces are usually operated at practically uniform temperatures and with a uniform atmospheric condition, usually reducing, as required by the major process. In a steam-boiler furnace the rate of heat input varies with the load, with the result that the atmospheric conditions in different parts of the furnace are not always identical and tend toward an oxidizing atmosphere in order to reduce carbon loss and to obtain the best thermal efficiency.

The slag-tap furnace as applied to steam boilers is a relatively new development brought about by the economic desirability of burning efficiently the cheapest heat units in the form of coal available at any given boiler-plant location and at the same time obtaining the higher and higher capacities and availability required from a single boiler unit. Some of the earlier slag-tap furnaces under steam boilers, however, copied features of metallurgical furnaces more closely than the conditions warranted. Although it was promptly recognized that some water cooling was necessary, its extent and character have been a process of development. The two principal difficulties with refractory-bottom furnaces were the expansion resulting in the opening and filling of cracks, and the inability of the furnace bottom to contract after each expansion period. A factor aggravating these difficulties has been the formation of iron sulphide from pyrites in the coal.

Practically all coal contains more or less iron pyrites and one molecule driven off when heated leaves iron sulphide which has a fusing temperature of about 1600 F and a very low viscosity so that it readily flows into cracks and crevices. Further, when heated much above its melting point it develops cutting or erosive characteristics so that when large quantities are present under such a condition, a small leak may quickly develop into a major flow. Aside from suitable furnace-bottom construction the best remedy for the iron-sulphide difficulty has been found to lie in the fine pulverization of the fuel which is then burned so completely that the iron is always in the form of an oxide instead of a sulphide and will therefore readily combine with other ingredients of the coal ash to form composite silicates of iron.

Experience has taught that the best furnace-bottom construction is one which is free from cracks and is so designed structurally that expansion will always be followed by corresponding contraction at reduced temperatures. Furnace bottoms should be cooled so that the heat penetration will be kept at a minimum both for economy in cost of structure as well as for quick accessibility to the furnace when it is taken out of service.

FLOOR CONSTRUCTION OF SLAG-TAP FURNACES

A completely water-cooled furnace with a floor consisting of cooling tubes covered with cast-iron blocks connected into the boiler circulation may be entered for inspection comfortably 8 to 10 hours after the boiler is taken out of service. This is possible because of the effective cooling provided by this form of construction and because the amount of slag undrained is relatively less than it is on a solid or other type of refractory floor.

A slag-tap boiler unit in operation may contain slag to a depth of from a few inches to a foot, the top surface of which is molten and at high temperature, disposed in the basin comprising the bottom of the furnace. The weight, character, and high total quantity of heat stored in this material demand that it be confined to that basin at all times, that the only outlet be through the regular tap hole, and that this outlet be under control.

For these reasons the furnace structure must include suitable support and rugged seals. It is advisable to provide horizontal buckstays capable of exerting a pressure of several thousand pounds per foot of wall between side walls and furnace-bottom edges to insure tightness against leaks. Bottom-supported walls may thus be held constantly in contact with the floor and can move on rollers as dictated by the normal expansion and contraction of the water-cooled structure through any cycle of into-and-out-of service.

INTERMITTENT AND CONTINUOUS TAPPING

Furnaces may be designed for either periodical or continuous tapping of slag. Where slag is tapped intermittently from a water-cooled bottom it is found that the slag is chilled for a certain distance up from this bottom so that after the fluid part is tapped off the viscous slag underneath gradually becomes molten and drains away to an equilibrium point beyond which the rate of tapping is insufficient for continuing the operation, thus ending the tapping period. The process of intermittent tapping requires some labor and operating attention. The time selected for tapping is generally that at which the load on the boiler is most favorable to quick and complete

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drainage. Most of the slag-tap boilers in service are tapped intermittently.

Continuous tapping is a later development on which the range of experience is not so broad as with the method previously described. However, it offers the possible advantages of less operating attention and a minimum of molten ash stored in the furnace at any one time. Broadly speaking, the principle of continuous tapping is based on keeping a fairly large tap hole, located centrally in the furnace bottom, free and open by withdrawing some of the hot furnace gases through the opening. Experiences to date with this method have been very successful.

In intermittent tapping the slag is tapped from one to three times per day, depending upon ratings run and the quantity of ash in the coal. Usually, one tap per day is sufficient and the slag level is lowered from three to six or eight inches. The stream is usually dropped onto a flat spray of multiple water jets to reduce it to the solid form and disintegrate it to the size of coarse sand. Additional jets then sluice it along to a sump or tank, or a pump may be used to discharge it directly to a dump.

From one to three hours are commonly required to tap. Slag streams emerging from the tap hole may be from a trickle to two inches or more in diameter. A flow of the latter size will be at the rate of a thousand pounds a minute or more.

Water-cooled liners are now universally used in slag spouts in this service. Service water at about 40 lb pressure is supplied in a quantity that permits an outlet water temperature below that at which scale will deposit. It is unnecessary, therefore, to treat this water, and by properly proportioning the liner circulating system a water which is moderately free from silt and undissolved solids may be used without sludge deposits.

A water-cooled liner permits slag flow over its surface without sticking and reduces attendance to a minimum while tapping. Hydraulically operated gates permit easy shut off and opening. Clay balls are usually used to plug the furnace aperture at the top of the spout. At the start of tapping this material is easily poked through with a rod.

Recent developments using continuous tapping are described by Grob in a recent A.S.M.E. paper.[1] Since there is a continuous flow of thin hot slag from all parts of the furnace toward a tap hole in the case of continuous tapping, water cooling of the floor in some manner is usually necessary to prevent progressive erosion which would take place on the surface of a refractory construction.

DESIRABILITY OF FINE COAL PULVERIZATION

The desirability of fine coal pulverization as a mitigating effect on the formation of iron sulphide has been previously mentioned. The success of slag-tap or wet-bottom furnaces is perhaps more dependent on fine pulverization than in the case of dry-bottom furnaces. High concentrations of heat on the slag-tap-furnace bottom and complete combustion in small volumes are facilitated by fine pulverization. Although finenesses varying slightly either way from 70 per cent through 200 mesh and 98 per cent through 50 mesh, depending on the coal characteristics, are generally considered satisfactory, recent developments in pulverizer control for direct firing make it possible to maintain consistently higher fineness at intermediate and low pulverizer outputs. In most types of boiler loading this makes it possible to pulverize a very high percentage of the total coal burned in a given period of finenesses ranging from, perhaps, 80 to 90 per cent through 200 mesh, with no increase in investment and with only a slight increase in power consumption. Full advantage of this increase in fineness is realized in the slag-tap furnace.

The use of an air heater with high preheat temperatures is a distinct advantage in the slag-tap furnace to the extent that it facilitates combustion and ash elimination. It is pertinent that there is no conflict between high preheat temperatures and satisfactory ash removal as there is in a dry-bottom furnace.

BURNER LOCATION

A wide range of experience has been obtained in the type and location of burners for slag-tap furnaces. The gamut has included tangentially located, straight-shot burners, tangential intertube, one-side firing with intertube and circular burners, one-side and opposed firing with cross-tube burners, and vertical firing from one side with multiple intertube burners. These experiences were dictated by a variety of factors. In the earlier applications it was customary to select a boiler and then apply a slag-tap furnace to it, which resulted at times in a distorted furnace, whereas present practice is in the direction of standard designs of the boiler and furnace as a unit with resultant improvements in both. The desired or existing boiler-room layout in the past has dictated the burner arrangement, and frequently still does, although the trend is definitely toward one-side firing as providing the most economical and satisfactory layout. Burners having the necessary capacities have been developed. In the earlier installations fuel and load characteristics were far more important factors in dictating burner and furnace arrangements than at the present time when the trend is toward universal rather than special designs to meet these requirements. Experience as regards horizontal versus vertical firing using turbulent burners has not fully crystallized the field for each, but in general the vertical burner arrangement lends itself better than the horizontal to high heat inputs per foot of width of furnace. A combination of vertical and horizontal burner arrangement permits using more of the furnace volume and achieves a wider load range for best economy and ability to tap at low loads. Burners for slag-tap furnaces must produce a short, snappy flame, in which the focal or hot spot is at the surface of the slag bed. It is especially necessary that the burners be built integral with the waterwall and be so designed that when the boiler is operated at partial load, burners out of service will not be damaged by the heat of the furnace.

By directing the burning fuel toward and along the surface of the fluid slag bed in the bottom of the furnace, some of the ash particles are caught. In a similar manner the wetted surface of the furnace envelope in the lower or high-temperature zone of the furnace catches additional ash which drains downwardly into the pool and discharges through the tap hole. Additional wetted surface supplied by a furnace slag screen further increases the catch of refuse and further reduces the amount that has to enter the boiler tubes, dust catchers, and terminal outlet.

TYPES OF WATERWALLS

In regard to the types of waterwalls required for slag-tap furnaces it is worthy of note that in the author's experience, which has been limited largely to the equipment of one manufacturer, it has not been necessary to develop new types of waterwall construction to meet the severe requirements of this

[1] "Slag Bottom Furnace Experiences at Hell Gate," by J. J. Grob, engineer of tests, United Electric Light & Power Company. Presented at a meeting of the Metropolitan Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, October 24, 1935.

class of service. The constructions extensively used are tubes covered with metal block and stud tubes. A protected tube construction has been found to be particularly necessary in the lower part of the furnace. On the more recent jobs and for all classes of service block-covered construction has been used in furnace bottoms.

As may be noted from some of the illustrations the more recent installations have combined the fully studded tube-wall construction in the high-temperature lower part of the furnace with a smooth-block construction in the upper part. This combination allows rapid cooling of hot ash particles by radiation to the cool upper wall areas and maintains hot sticky wall surfaces adjacent to the slag bed and around the zone where combustion is most active and where it must be completed in as short a time as possible.

TYPICAL INSTALLATIONS

Fig. 1 shows a steam-generating unit first put in service in April, 1933, and designed for an operating pressure of 450 lb per sq in. and a maximum output of 350,000 lb of steam per hr at 763 F total temperature, to burn pulverized Pennsylvania, Ohio, and West Virginia coals having fusion temperatures ranging from 2200 to 2500 F. A single slag spout is located in the center of the rear wall opposite vertical burners disposed in the arch. The entire furnace including the floor is constructed of block-covered water-cooled tubes. The total heat liberation in the furnace is 34,800 Btu per cu ft per hr, and the liberation per front foot, or per foot of boiler width, is 17,500,000 Btu per hr.

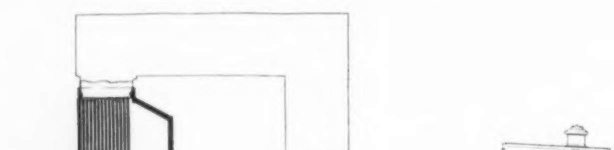

FIG. 1 SLAG-TAP FURNACE IN WHICH WALLS AND FLOOR CONSIST OF BLOCK-COVERED WATER-COOLED TUBES

(The tapping spout is in the center of the rear wall.)

The coals actually burned have varied in ash-fusion temperature from 2100 to 2520 F. Total sulphur in the coal has varied from about 1.5 to 3 per cent. Slag is tapped once every 24 hours when operating at maximum output and two to three times per week under other conditions.

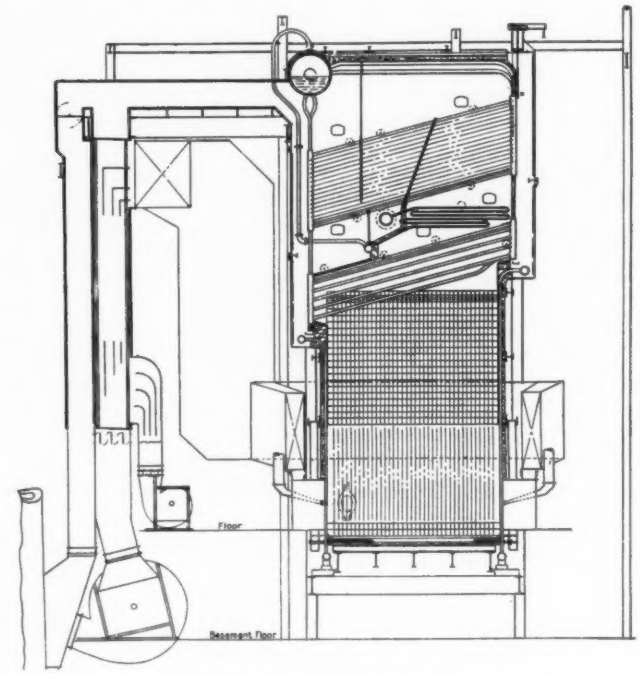

FIG. 2 SLAG-TAP FURNACE WITH OPPOSED FIRING FROM CROSS-TUBE BURNERS

(Slag spout, which is not shown, is in one side wall and discharges to jet sprays in a disintegrating chamber.)

Fig. 2 shows a unit first placed in service in February, 1934. It was designed for a maximum output of 285,000 lb of steam at a total temperature of 740 F to burn Ohio coal with an ash-fusion temperature of about 2100 F. This unit usually operates continually at or above the maximum design figure. The secondary-air temperature is 550 F. At a steaming rate of 285,000 lb per hr the total heat liberation is 32,700 Btu per cu ft and the liberation per front foot is 21,000,000 Btu.

Opposed firing is provided from two cross-tube burners per side. The slag spout, not shown in the illustration, is located in one side wall and discharges to jet sprays in a disintegrating chamber. A dewatering tank then catches the disintegrated slag, which is emptied periodically to a bucket conveyor for final disposal. The ash content of the coal used is about 12 per cent and slag is tapped for an hour or two every eight to twelve hours. The entire furnace and floor is water-cooled and smooth blocks cover the floor tubes. The lower portion of the furnace walls is of full-stud covered tubes. The bare cast-iron block construction in the upper portion of the furnace provides an effective and adequate cooling surface for cooling ash particles by radiation below the point where they would give trouble in the boiler tube bank.

The construction shown in Fig. 3 is that of two units first placed in service in November, 1933, and January, 1934, designed for a maximum steam pressure of 730 lb per sq in. and a steam output of 375,000 lb per hr at 835 F total temperature.

The total furnace liberation at this output is 39,750 Btu per cu ft, corresponding to a liberation per front foot of 23,000,000 Btu per hr.

The design was based on the burning of a wide range of Pennsylvania, Maryland, and West Virginia coals having ash-fusion temperatures ranging from 2000 to 2600 F. The coals actually burned have had ash-fusion temperatures of from 2100 to 2580 F.

The furnace is completely water-cooled and the lower portion is of full-stud construction. The floor and upper portion are of smooth cast-iron blocks. The furnace screen shown shades the boiler tubes from the intense radiation in the lower part of the furnace and, by reflection of heat downward onto the floor slag, assists tapping at low ratings. Two rows of turbulent multiple intertube burners deliver the burning fuel toward the slag surface on the floor. Tapping is done through a single spout which is located in the center of the rear wall.

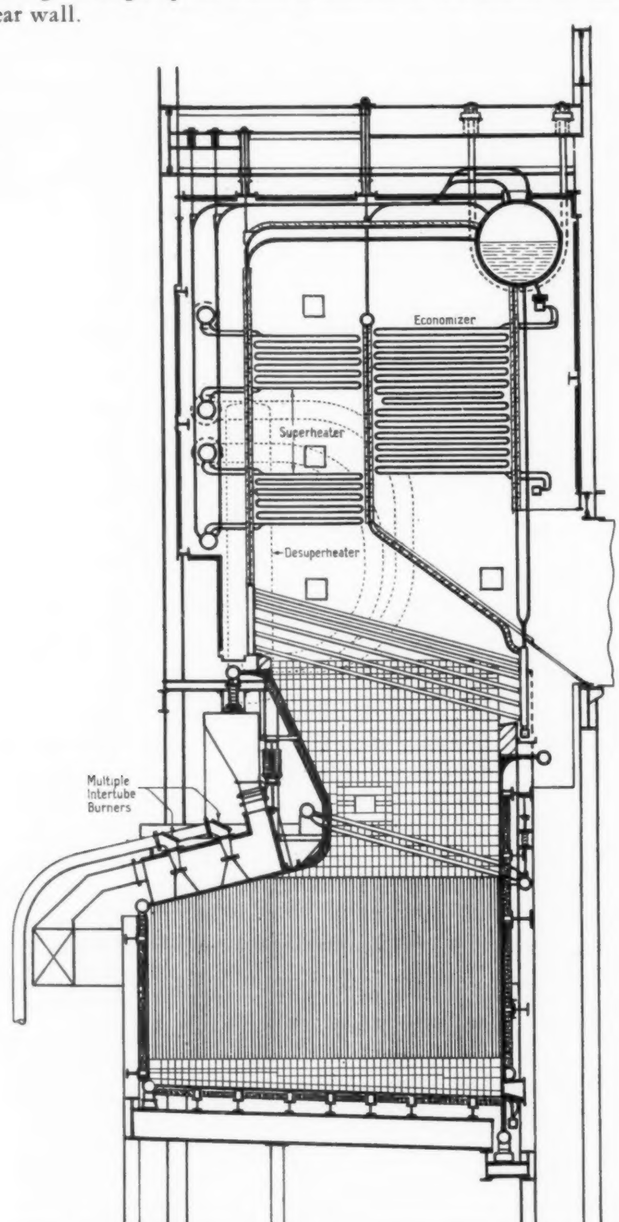

FIG. 3 SLAG-TAP FURNACE WITH FURNACE SLAG SCREEN
(Tapped through a single spout in center of rear wall.)

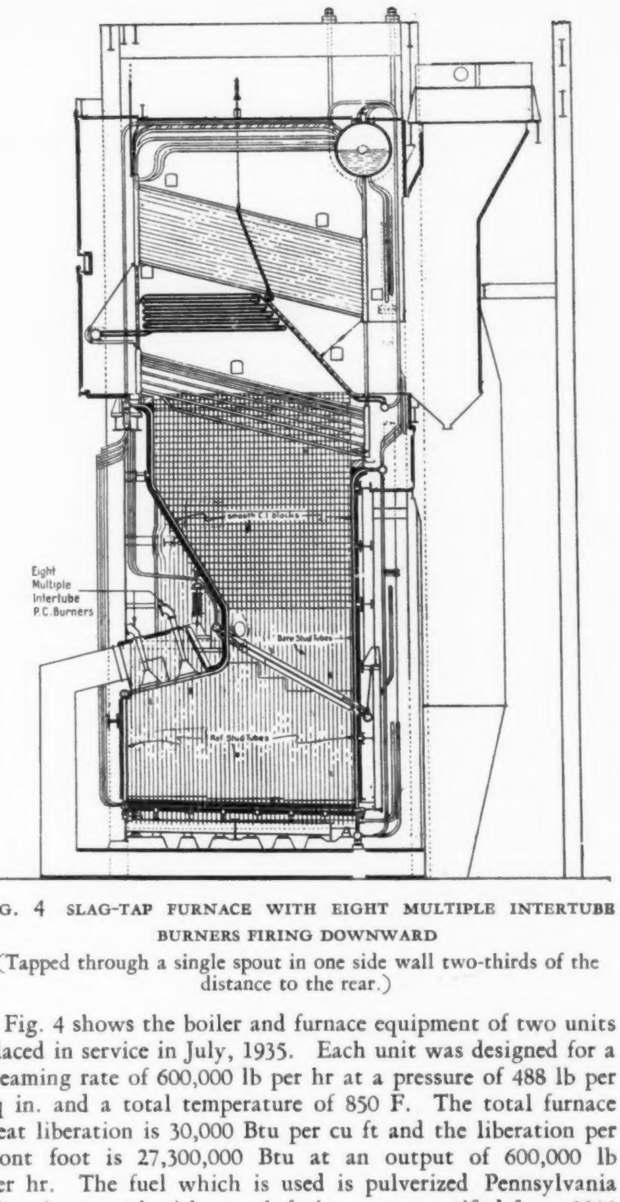

FIG. 4 SLAG-TAP FURNACE WITH EIGHT MULTIPLE INTERTUBE BURNERS FIRING DOWNWARD
(Tapped through a single spout in one side wall two-thirds of the distance to the rear.)

Fig. 4 shows the boiler and furnace equipment of two units placed in service in July, 1935. Each unit was designed for a steaming rate of 600,000 lb per hr at a pressure of 488 lb per sq in. and a total temperature of 850 F. The total furnace heat liberation is 30,000 Btu per cu ft and the liberation per front foot is 27,300,000 Btu at an output of 600,000 lb per hr. The fuel which is used is pulverized Pennsylvania bituminous coal with an ash-fusion range specified from 1800 to 2500 F.

These units operate at a high continuous output between 550,000 and 680,000 lb per hr. The coal actually used has had an ash-fusion temperature varying between 2300 and 2590 F.

Eight multiple intertube burners fire downward through the front arch against the slag surface and slag is tapped once per day through a single spout about two-thirds the distance back in one side wall. The furnace slag screen shown facilitates tapping at low rating, and it has been possible to tap ash having a high fusing temperature at a rate of 250,000 lb per hr. The lower part of the completely water-cooled furnace is equipped with full-stud tubes and the floor tubes are covered with smooth blocks. The upper part of the furnace has smooth-block-covered tubes for the rapid cooling of ash particles before they reach the boiler tubes.

Fig. 5 shows the design of three units placed in service in August and September, 1931, to burn pulverized Illinois coal with a maximum steam output of 495,000 lb per hr at a working pressure of 650 lb per sq in. and a total temperature of 760 F.

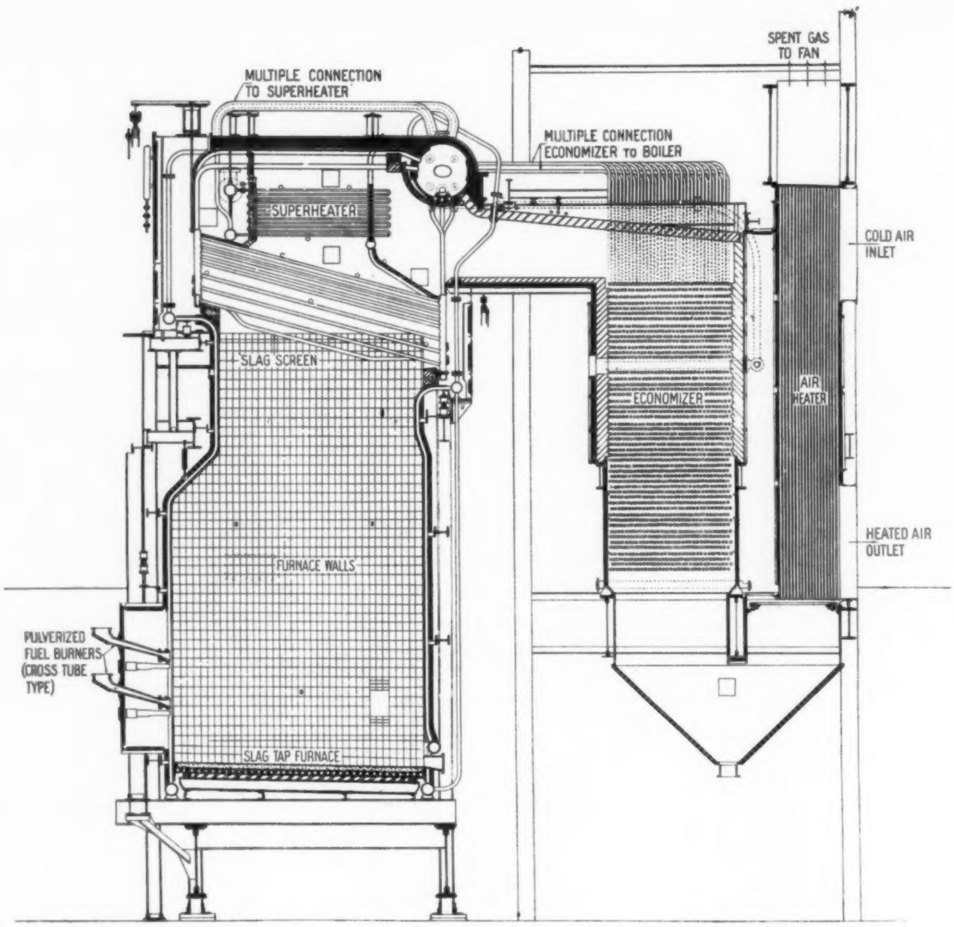

FIG. 5 SLAG-TAP FURNACE EQUIPPED WITH TWO ROWS OF CROSS-TUBE BURNERS ON ONE SIDE
(Tapped through two spouts in rear wall.)

The completely water-cooled furnace is covered with blocks, including a portion of the floor-tube area.

The rest of the floor tubes are bare, bedded in, and with a covering of plastic chrome refractory. The heat liberation in the furnace is 26,200 Btu per cu ft, corresponding to 15,800,000 Btu per front foot.

The furnace is direct fired by two rows of cross-tube burners from one side, and tapping is done through two spouts located in the rear wall opposite the burners. The floor tubes run transversely across the furnace with a general drain from all directions toward the spouts.

SUMMARY

There are in service now more than 80 slag-tap furnaces operating on coals with ash-fusion temperatures ranging from 1900 to 2550 F. The most recent practice is extending the use of this type of furnace into even higher values of ash-fusion temperature. The units are distributed over practically every section of the country where coal is burned and are not withheld from any particular class of coal except those having the very highest ash-fusion temperatures.

Coals having low ash-fusion temperatures and high sulphur content that sometimes are marketed with difficulty are easily handled in a slag-tap furnace. By suitable floor design and by fine pulverization to permit rapid oxidation of iron pyrites, earlier troubles from this source have been eliminated.

Bottom support of furnace walls permits little or no relative vertical expansion of walls and floor, since the floor and wall support may be at the same elevation. This construction simplifies the problem of sealing the basin, and, together with strong buckstay reactions, insures tightness around the basin's boundary.

Simple service-water cooling of the slag spout has practically eliminated spout maintenance and has made the tapping operation easy.

Firing from one side, either with vertical or with a combination of vertical and horizontal turbulent burners, utilizes the furnace volume fully, makes it possible to apply high heat to the surface of the slag and this arrangement is usually more suitable to bunker and pulverizer location in a boiler room.

ADVANTAGES OF THE SLAG-TAP FURNACE

As a result of the experience to date with a relatively large number of slag-tap installations, the author is able to present the following list of advantages that he has seen realized through the use of the slag-tap furnace:

(1) It is with but few exceptions adapted to burning at highest combustion efficiency the cheapest fuel heat units at any given boiler-plant location.

(2) It is inherently well adapted to the high capacities and high availability required of modern steam-boiler units, because, with it, there is no conflict between high furnace capacity and satisfactory ash removal, even with the use of low-grade bituminous coal.

(3) It is economical in size, shape, and waterwall areas as well as in building space required.

(4) It imposes fewer limitations upon the design of the boiler proper for high-capacity steam-boiler units.

(5) The high temperatures maintained in the lower part of the furnace promote rapid and complete combustion. The molten-slag pool serves as a stabilizer of combustion and ignition.

(6) It delivers a minimum quantity of ash to the passes of the boiler, heat traps, and stack.

(7) Fine ash from soot hoppers and dust precipitators may be drained back into the furnace slag pool for melting and subsequent least troublesome disposal. This is now being done in a limited way, but further development is required.

(8) Removal of ash in fluid form is clean and dustless. A simple and movable pipe-line transport for fill purposes may be used.

THE "SOCIAL CREDIT" CONCEPT

By E. R. LIVERNASH

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THE popular appeal of the purchasing-power panacea during a period of depression cannot be denied. Whether the particular plan be dressed in the evening clothes of Major Douglas, the more simple garb of the Townsend plan, or the many and varied costumes of the New Deal, its common acceptance rests upon a logic of recovery by means of increasing purchasing power. However, too much of our reasoning on the subject takes "purchasing power" and "money" as synonymous terms, and thereby endorses any plan which proposes putting more money into circulation. Failure to distinguish between mere shifts in purchasing power from one class or group to another and actual increases in purchasing power, and failure to realize the intricate problems involved in the relationship of money, goods, and prices, which are included in the concept of purchasing power, have made the use of that term largely meaningless. Let us, then, analyze Major Douglas' plan[1] as to its content, causes, and validity in an attempt to see whether he has contributed anything worthy of incorporation into our economic system.

The content of Major Douglas' plan can best be set forth by presenting the salient features of his "Draft Social Credit Scheme for Scotland":

(1) Set up a capital account for Scotland containing the capitalized value of the physical assets of the country and the population.

(2) Distribute monthly by means of drafts upon the Scottish government credit, an arbitrary percentage of the capital account to every man, woman, and child in Scotland (with certain limiting qualifications).

(3) Register all businesses under an assisted-price scheme. All consumers buying from these businesses are to be credited by the banks to the extent of a certain arbitrary "discount" on the amount of their total purchases. The total sum credited by the banks to private depositors in respect of these discounts is to be reimbursed to the banks by Scottish treasury credit.

(4) Wage rates in all organized industries are to be reduced by a certain arbitrary percentage; however, the reduction must not mean a loss to the individual wage recipient greater than 20 per cent of his monthly national dividend.

With "social credit" in operation, "purchasing power" would no longer be distributed solely through wages, interest payments, and dividends. A certain number of people in the community would receive an equal share of the monthly social-credit payment. The reduction of wage rates would reduce the money income of wage earners as individuals; however, the proviso that the loss to any individual cannot exceed 20 per cent of his payment from the national dividend indicates that the money income of wage earners is intended to be larger than before the initiation of the social-credit plan. In addition, consumers are reimbursed by the banks (the banks being reimbursed by the government) to the extent of an arbitrary percentage of their total purchases from registered businesses. The profit to business producers is apparently increased through the reduction of wage costs with the maintenance of prices at the old level, and through the increased volume of business made possible by the increase in purchasing power resulting from the monthly government dividend payments, and the recrediting to consumers' accounts of a fraction of their total purchases.

Wherein this plan is essentially different from the "printing press" method of stimulating production, which has brought such disastrous consequences wherever it has been resorted to, is difficult to see. One immediately wonders if the primary effect of the plan would not be simply an increase in prices. Major Douglas does not intend to bring about such a result. He inveighs against the evils of inflation, and says, "there is almost nothing to be said for a policy of deflation." It appears that social credit is not supposed to be either "inflationary" or "deflationary." Whether this statement implies a constant average of prices is open to conjecture. But the arbitrary nature of the discount rate, the amount of the dividend, and the reduction of wage costs makes the plan meaningless apart from the reasons Major Douglas advances for the issuance of social credit. Let us, therefore, turn to an analysis of the conditions leading Major Douglas to believe such a plan desirable and necessary.

Major Douglas believes that our present economic system is based upon a false assumption of scarcity. This assumption has become ingrained in our legal and social institutions. We strive for a goal of full employment which is no longer justifiable because of technological advance. The banking institutions, working upon a thesis of scarcity and desiring economic power, unduly limit the supply of money. Society has now come to an impasse. "Human intelligence has progressed to the extent that a method of stimulating industry similar to the holding of a carrot continuously in front of a donkey's nose to produce progress, has ceased to function effectively. Even an ass has a rudimentary sense of proportion between miles walked and carrots achieved." The people, realizing the paucity of carrots achieved, should be allowed to vote on the issue: "Do you want employment or do you want goods?"

While we agree with Major Douglas on the outcome of such an election, the antithesis between securing "goods" or "employment," even with the existing technological capacity, is highly at variance with the fundamental assumptions of economic theory. If one grants that (1) human wants taken in the aggregate are insatiable, and (2) productive means are scarce relative to these wants, then technological progress signifies the more complete satisfaction of existing desires and the partial satisfaction of new desires. It is difficult to believe that technological advance has brought us to the jumping-off place where we are confronted with the problem of abundance in which full employment and increased wealth are antithetical.

But Major Douglas maintains that technological progress has reached the stage where employment should no longer constitute the means of obtaining "tickets" to wealth. It is here that our money system, which is based upon the false assumption of scarcity, checks production. One must have

[1] "Social Credit," by C. H. Douglas. W. W. Norton & Co., New York, 1933.

Ninth of a series of reviews of current economic problems affecting engineering, prepared by members of the Department of Economics and Social Science, Massachusetts Institute of Technology, at the request and under the sponsorship of the Management Division of The American Society of Mechanical Engineers.

tickets to stimulate production. Tickets are obtained primarily through employment. Full employment is no longer possible because of technological advance, so we must devise a scheme for passing out tickets which does not require labor to be given in advance.

The main fault with the present ticket system which prevents the utilization of productive capacity, and constitutes the direct reason for social credit, is that "costs are less than prices."

> The collective prices of goods available for sale at any moment in a given community, if they have been produced by ordinary commercial methods, cannot be met by the money available through the channels of wages, salaries, and dividends, at one and the same moment.

And, as a corollary:

> This situation would be almost immediately destructive to the working of the business system, if the financial technique did not provide a source of purchasing power, or new money, in the form of bank loans and credit instruments, paid for past production.

Apparently we have reached our present stage of advancement by the use of the technique of bank credit. But because of our concepts of legal ownership, progress literally belongs to the bankers. "Industry has become mortgaged to the banking system." The bankers then profit by their control and create artificial scarcity which prevents the full utilization of productive capacity. "The fact that there is no physical limitation to the satisfaction of reasonable material requirements—that in fact there is no such thing in the modern world, with the exception of Russia, as a poor country in any sense other than that of a scarcity of tickets to operate satisfactorily as purchasing power—only serves to transfer the exhortation to be thrifty, from goods of which there is a surfeit, to money of which there is a scarcity."

Let us observe, however, that this entire philosophy, in addition to being based upon an assumption of an economy of abundance, requires this mechanical defect of costs being less than collective prices which makes bank loans necessary and allows control to pass to the bankers. The heart of Major Douglas' argument is found in the statement that collective prices of goods produced in a given period are less than wages, salaries, and dividends paid out in that period.

Apparently Major Douglas means that if one were to add up the selling prices of all goods produced during a given time period, let us say one month, and all of the money paid out in wages, salaries, and dividends, he would find collective prices were greater than these items of cost. But what prices are we to include in this term "collective prices?" The prices of raw materials, machinery, etc., are of no direct concern to consumers. It is only necessary that sufficient purchasing power be in the hands of consumers to buy what we may term "consumers' goods." Now it is obvious that if we double-count certain goods—count in collective prices semifinished goods and completed goods—wages, salaries, and dividends will be less than collective prices for the period; however, this is of no consequence, for consumers have only to purchase the completed goods.

But will enough be paid out to purchase the completed goods? The answer seems to be in the affirmative, though one might quibble as to whether the payments to income recipients could all be classified as wages, salaries, and dividends. If one considers the entire productive process of bringing a particular good to the market, it is difficult to see wherein there is any "leakage" of money. Each element entering into the price has been "paid out" in purchasing power to some income recipient. While it is true that money paid out in the production of a specific good may return to the producer of a different good, and that changes in demand will bring about changes in the types and quantities of the particular goods purchased, these changes do not represent any inherent defect in the monetary system.

Nor does the time period present any mechanical defect. Let us think of the production of a particular good as involving four stages (time and technological stages). Now while each particular article must pass through all four stages, in any one time period goods of all stages are being produced and sufficient purchasing power is paid out to buy the products finished during that period. While changes in demand, volume of saving and investment, and other factors complicate the smooth flow of money against goods, and often bring about maladjustments both in the price and goods structure—all of which have important bearing upon the business cycle—there is no mechanical defect in the monetary system which constantly operates to make the purchasing power created less than the purchasing power required.

Although we have found no proof in Major Douglas' work of a deficiency of purchasing power, his belief in such a deficiency provides the basis for the administration of his plan for "social credit." The monthly dividend paid out to consumers is designed to eliminate that deficiency. It would not be "inflationary" nor "deflationary" because prices would not be affected; the additional credit would simply provide the means of removing the goods from the market which cannot be purchased under present commercial methods. Under present commercial methods those surplus goods must be destroyed, exported, or purchased by new bank credit created. Destruction is an evil in itslf; the struggle for export markets leads to war; purchase by new bank-credit mortgages industry to the banking institutions. However, if such a deficiency of purchasing power does not exist, what would be the effect of the plan for social credit?

We would expect the primary effect to be an increase in prices, coupled with a rapid increase in the national debt. Though social credit was not designed primarily as a depression remedy, the popularity of the plan can be attributed only to the present business conditions. But passing out money or credit is no sure-fire method of bringing back prosperity. Purchasing power is in general a result and not a cause of business activity. We hear no complaints of a lack of purchasing power during prosperous years, nor do we find explanations of business prosperity in terms of too much purchasing power. In addition, if a lack of purchasing power created a depression, we would expect to find prices and profits decreasing first in the consumer-goods industries where that lack would be felt. As a matter of fact, the depression hits first in the heavy industries, and only at a later stage are prices and profits in consumer-goods industries affected.

As a lack of purchasing power does not seem to cause, but rather to accompany, business recession, we would hardly expect an increase in purchasing power to cause prosperity. Even if we could pass out money more rapidly than prices rise, thus increasing purchasing power, and possibly stimulate consumer-goods industries, there is reason to believe that the heavy industries (the core of the cycle) would be affected very little.

While Major Douglas' proposals have for some time been prominent, primarily as a means of countering the business depression, we find that they contain little constructive material. Social credit is no cure for depression, nor does it seem justified as a general reform in our economic system, necessitated by advancing technology and a ticket system that is faulty.

1935 A.S.M.E. ANNUAL MEETING

A Review of Society and Technical Events

THE BREADTH of interests of The American Society of Mechanical Engineers was again forcibly illustrated by the extent and variety of subject matter offered in papers and discussions at the Fifty-Sixth Annual Meeting, held at the Engineering Societies Building, New York, N. Y., December 2 to 6, 1935; and serves as justification, if any is needed, for the announced intention of the incoming president, W. L. Batt, to devote his energies to the closer relationship of all members of the profession and of the national engineering societies. While no attendance record was broken, the total registration of 2097 is evidence of the importance of these annual engineering meetings, for in times when the long-continued depression has left its mark on the capital-goods industries which chiefly support the activities of mechanical engineers, this number is an impressive one. Included in the registration total were 763 guests and 135 women.

WILLIAM L. BATT, PRESIDENT, 1936
THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

LOCAL SECTIONS DELEGATES

Throughout October and November, in seven geographical districts covering the entire United States, representatives of the local sections of the Society met at central points to discuss common problems and to elect two delegates each to attend the Annual Meeting in New York. The names of these fourteen delegates, and the groups they represented, are as follows:

GROUP 1: W. L. Edel, Storrs, Conn., and Z. R. Bliss, Providence, R. I.

GROUP 2: Theodore Baumeister, Jr., New York, N. Y., and J. N. Landis, Brooklyn, N. Y.

GROUP 3: B. F. Rogers, Kingston, Pa., and R. S. Brescka, Cranford, N. J.

GROUP 4: S. B. Earle, Clemson College, S. C., and John P. Ferris, Knoxville, Tenn.

GROUP 5: S. R. Beitler, Columbus, Ohio, and Sabin Crocker, Detroit, Mich.

GROUP 6: R. M. Barnes, Iowa City, Ia., and E. L. McDonald, Kansas City, Mo.

GROUP 7: S. R. Dows, San Francisco, Calif., and David R. Gray, Spokane, Wash.

This group of men met on Sunday, December 1, and commenced the discussion of the numerous resolutions and matters of policy and inquiry that each of them had brought from his individual group conference. In the evening a buffet supper provided an opportunity for informal acquaintanceship with members of the Council, following which President Flanders read the complete report of Referee Philip J. Sinnott to the Supreme Court of the State of New York in the matter of litigation brought by John Parker. To questions and discussion that followed, Mr. Flanders, Secretary Davies, and members of the Council, past and present, who had been concerned in the hearings, gave further explanations. It was pointed out by President Flanders that while the report was favorable to the Society, the case was not disposed of, as it would still be necessary for the court to whom the report was addressed to render a decision.

PARKER LITIGATION

The referee's report, which covers fourteen closely typed pages, will not be reproduced here. Certain significant paragraphs and the conclusions of law were read by President Flanders at the Annual Business Meeting of the Society on Monday afternoon. For the purposes of this account, only the conclusions of law are quoted from the referee's report. These are as follows:

CONCLUSIONS OF LAW

1 I find that none of the property or funds of The American Society of Mechanical Engineers has been misappropriated or diverted to any other purpose than that for which such Society was incorporated.

2 I find that said Society has not been engaged in any other business than that specified in its Certificate or Act of Incorporation.

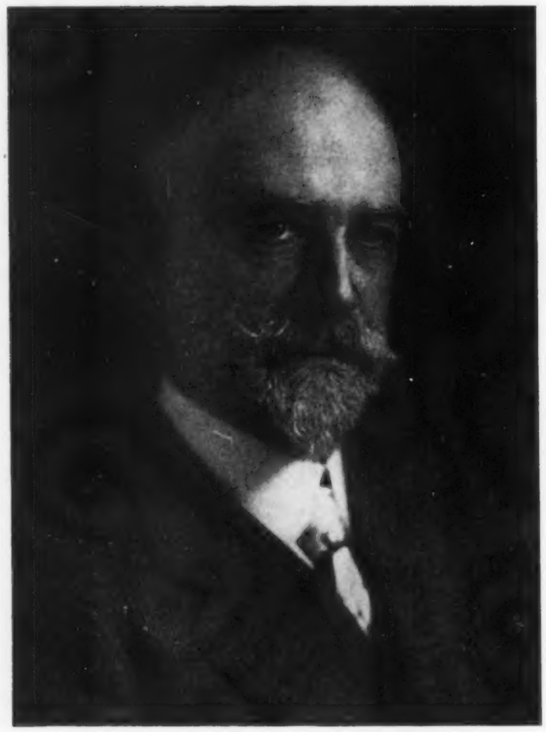
3 I find that the said Society's acts and transactions reviewed before me were properly had and done within its lawful discretionary right and power, and that there is no ground for any judicial condemnation thereof, or interference therewith.

Copies of the complete report were mimeographed and distributed at the meeting.

FURTHER ACTIVITIES OF LOCAL SECTIONS DELEGATES

Throughout the remainder of the week the local sections delegates were almost continuously in session, interrupting their own deliberations to join in such other gatherings as the Business Meeting, Council meetings, and the social events that were featured in the evenings.

One of the most important actions of the delegates was the completion of a permanent organization which provides for continuity of action by this body. This arrangement was made possible by the selection of two delegates from each group, one to serve one year and one to serve two years. In the future one delegate will be selected annually for a period of two years. This permanent organization of delegates will have a speaker, an alternate speaker, and a secretary. Another feature of the new organization is that the delegate in his second year of service will also act as chairman of the group organization in his district.



WILLIAM F. DURAND
RECIPIENT OF JOHN FRITZ MEDAL

Another high spot was President Batt's announcement to the delegates that it was his intention to ask the senior member of the Council in the territory of each group to be responsible for the activities of the local sections in that area. It is expected that the Council member will undertake to visit each of the sections in his district in order to obtain accurate knowledge of the functioning of the Society and also to afford opportunity for members in various parts of the country to confer with members of Council.

The delegates also attended the customary luncheon with the Council and members of standing committees and professional-divisions officers at the Hotel Astor on Monday. This group was addressed by President Flanders and President-Elect Batt. Mr. Batt announced his intention to visit all local sections and student branches not visited by his predecessor.

EXECUTIVE COMMITTEE OF COUNCIL

On Sunday noon, December 1, the Executive Committee of the Council met for luncheon and for the transaction of business. Actions of general interest were as follows:

A.E.C. REPRESENTATIVES

A.S.M.E. representatives and alternates on the American Engineering Council for 1936 were appointed: W. L. Batt, chairman, L. P. Alford, Paul Doty, R. E. Flanders, and J. W. Roe; alternates, E. W. O'Brien and E. L. Ohle.

BOARD OF REVIEW

It was recommended that the Council delegate to the Board of Review the duty of reviewing resignations and cases of delinquents, and the formation of a new policy in these matters. The resignation from the Board of Review of H. B. Oatley was noted with regret. As yet, no new appointment has been made.

Upon recommendation of the Committee on Local Sections it was voted to extend to June 30, 1936, the limiting final date for transfer to junior membership of student members graduated with the class of 1935.

BOILER-FEEDWATER STUDIES

The Committee noted that agreements of the Joint Research Committee on Boiler Feedwater with the University of Michigan and between the Department of the Interior and the A.S.M.E. on research work on boiler-water treatment were to be continued. The Committee also approved in principle the patent agreement signed by W. C. Schroeder covering work at the Nonmetallic Minerals Experiment Station of the U. S. Bureau of Mines at New Brunswick, N. J., for the Subcommittee on Alkalinity and Sulphate Relations in Boiler-Water Salines.

COOPERATIVE RELATIONS

The Special Committee on Cooperative Relations was discharged with expressions of appreciation for its completed work.

RESIGNATIONS

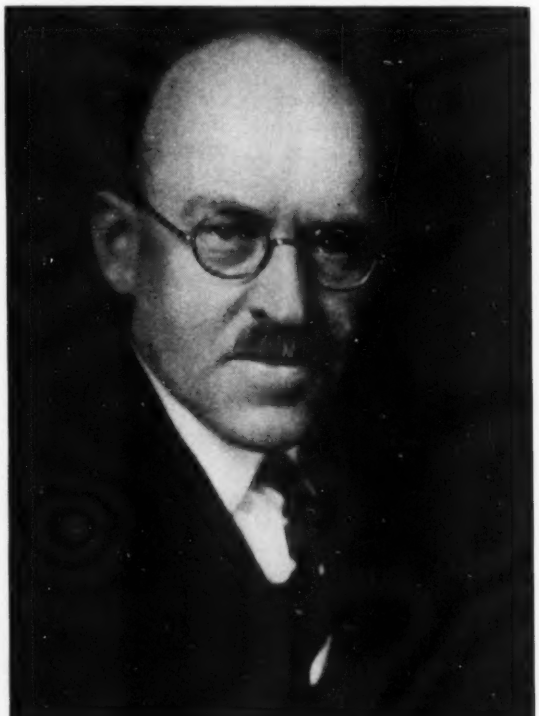
The resignation of A. A. Potter as chairman of the Advisory Board on Technology and that of Erik Oberg, for 10 years treasurer of the Society, were received with regret.

NATIONAL BUREAU OF ENGINEERING REGISTRATION

James H. Herron was appointed to the advisory board of the National Bureau of Engineering Registration, to replace J. H. Lawrence, resigned.

EDISON FOUNDATION

The invitation to the Society from the Thomas Alva Edison Foundation, Inc., to nominate a representative to serve as a



RALPH E. FLANDERS
TOWNE LECTURER

director on a committee whose objectives are (1) aiding youth through education in the advancement of science, (2) preservation of library, laboratory, and other buildings of Mr. Edison's at West Orange, N. J., and the erection of a fireproof building to contain his original apparatus and records, (3) making permanent the present temporary tower at Menlo Park, and (4) providing a final resting place for Mr. Edison, was referred to the president with power.

WATT BICENTENARY

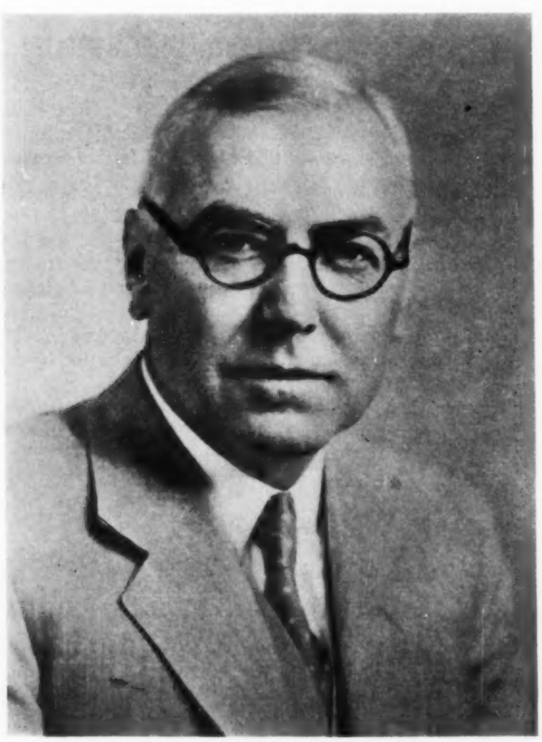
It was voted to accept the invitation of Lehigh University to participate in the celebration, Jan. 20, 1936, of the bicentennial of the birth of James Watt. (See page 66.)

APPOINTMENTS

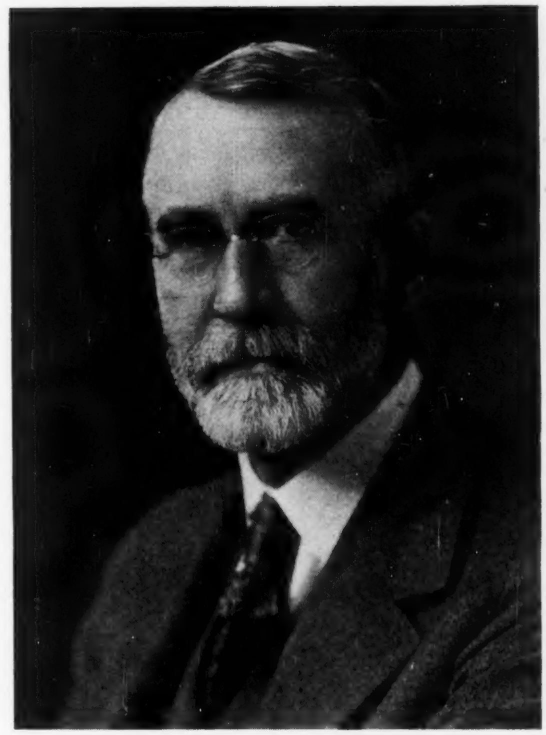
The following appointments and reappointments were confirmed, as honorary chairmen of student branches at the institutions named: H. V. Beck, Oklahoma University; B. H. Jennings, Lehigh University; N. P. Bailey, Rutgers University; J. M. Gallalee, University of Alabama; J. W. Zeller, Northeastern University; Herbert S. Philbrick, Northwestern University; J. S. Morehouse, Villanova College; H. F. Gauss, University of Idaho; C. A. Joerger, University of Cincinnati; James Holt, Massachusetts Institute of Technology; R. R. Slaymaker, Southern Methodist University; G. B. Karelitz, Columbia University; Vincent W. Young, Oklahoma A. and M. College; E. H. Sager, Washington University, and Harry L. Daasch, Iowa State College.

COUNCIL MEETINGS

In accordance with custom, the A.S.M.E. Council held two meetings, the first on Monday morning, which was adjourned to that afternoon when the local sections delegates were in attendance, and the second on Friday. Friday's meeting, as



CHARLES H. PURCELL
THURSTON LECTURER



CHARLES T. MAIN
RECIPIENT OF A.S.M.E. MEDAL

usual, consisted of two sessions as the 1935–1936 Council met immediately after the adjournment of the 1934–1935 Council, thus inaugurating a new administrative year.

Actions of general interest taken at these several sessions of the Council were as follows:

ANNUAL REPORTS

Following approval of business from the Executive Committee, already mentioned, the annual report of the Council and of its administrative and other committees were approved. In some cases chairmen of the committees reporting made personal presentations of important items contained in their reports. Printed copies of the reports are available, and will reach every member of the Society in a second section of the A.S.M.E. Transactions for January, that will be mailed about Jan. 10, 1936.

MANUAL ON CITIZENSHIP

At the request of the Committee on Citizenship it was voted to adopt "The Engineer's Duty as a Citizen," by Roy V. Wright (see MECHANICAL ENGINEERING, April, 1935, pp. 209–210) as the manual of the Society for use with junior and student-branch activities, and to refer the matter of distribution and expenditures involved to the Committee on Relations With Colleges.

PROFESSIONAL DIVISIONS

For the Committee on Professional Divisions, W. A. Shoudy, chairman, presented a special report on a proposed reorganization of this activity and asked for instructions. It was voted to approve in principle the report and to submit it to representatives of the divisions for recommendations to the Committee on Professional Divisions. It is hoped that the report will be published at an early date.

WILLIAM A. SHOUDY
Elected Vice-President

R. L. SACKETT
Elected Vice-President

JAMES W. PARKER
Elected Manager

W. C. LINDEMANN
Elected Manager

ENGINEERING HISTORY

The proposal to establish a joint committee on engineering history (A.S.C.E., A.I.M.E., A.S.M.E., A.I.E.E., A.I.Ch.E., and the Engineering Societies Library) was discussed, and it was voted to seek the suggestions of the United Engineering Trustees, Inc.

NEW MEMBERSHIP GRADES

In view of the vote of the Society to set up new grades of membership (see MECHANICAL ENGINEERING, August, 1935, p. 532) it was noted to refer to the Committee on Admissions[1] the details of handling changes in membership that are involved. The following amendments to the By-Laws and Rules were adopted:

AMENDMENTS TO BY-LAWS

Article B4, Qualifications for Admission

Par. 6 All matters relating to, admissions to, and promotion in, membership in the Society shall be in charge of the Committee on Admissions under the direction of the Council.

Article B5, Fees and Dues

Par. 13 (addition) The annual dues for a Student-member shall be $3 for the fiscal year beginning October first. Eight issues of MECHANICAL ENGINEERING, October to May, inclusive, shall be included in the dues of a Student-member.

Article B8, Council

Par. 19 The Standing Committee on Admissions shall determine the eligibility of applicants for membership, and for transfer in membership grades, and shall make recommendation to the Council on each. The Committee shall consist of five (5) members, and the term of one member shall expire at the close of each Annual Meeting.

PROPOSED AMENDMENTS TO RULES

Article R3, Membership

Rule 3 Abbreviations of the titles to be used by members are as follows:

Honorary Member	Hon. Mem. A.S.M.E.
Fellow	Fellow A.S.M.E.
Member	Mem. A.S.M.E.
Associate	Assoc. A.S.M.E.
Junior	Jun. A.S.M.E.
Student-Member	Student A.S.M.E.

Article R4, Qualifications for Admission

Rule 1 A candidate for admission to the Society as a Fellow, a Member, or an Associate, should refer to at least five (5) members who have personal knowledge of his qualifications and the grade of reference shall be as follows:

For Fellow, at least one (1) Fellow and the remainder Members
For Member, at least five (5) Fellows or Members
For Associate, at least three (3) Fellows or Members and the remainder Associates.

Rule 2 A candidate for admission to the Society as a Junior should refer to at least three (3) members who have personal knowledge of his qualifications, at least one of whom shall be a Fellow, Member, or Associate.

Rule 3 (addition) A candidate for admission to the Society as a Student-member must be endorsed by the Honorary Chairman in office at the Student Branch located at the college where he is a student.

Change former Rule 3 to Rule 4.
Change former Rule 4 to Rule 5 and change "Membership Committee" to "Committee on Admissions."
Change former Rule 5 to Rule 6, and change "Membership Committee" to "Committee on Admissions."
Change former Rule 6 to Rule 7 and change "Membership Committee" to "Committee on Admissions."

Rule 8 All confidential correspondence in relation to each candidate shall be destroyed by the administrative officer in charge of membership admissions within a reasonable period after acceptance of election by payment of the initiation or transfer fees and dues.

Change former Rule 8 to Rule 9 and change "Membership Committee" to "Committee on Admissions."
Change former Rule 9 to Rule 10.

Article R5, Fees and Dues

Former Rule 1 to be omitted.
Change former Rule 2 to Rule 1.

Article R8, Council

Rule 1 Change "Membership Committee" to "Committee on Admissions."

JAMES WATT BUST

The gift of the American Society of Civil Engineers of a marble bust of James Watt, for several years in the possession of that society, to the A.S.M.E. was announced. The bust, which is now in the Society's rooms, is a particularly appropriate gift in view of the bicentennial celebration of the birth of James Watt. A vote of thanks and appreciation was recorded.

[1] With the adoption of the amendments to the By-Laws and Rules at this meeting, the name of the Committee on Membership was changed to Committee on A dmissions.

WORLD POWER CONFERENCE

Correspondence between R. E. Flanders and O. C. Merrill, director, Third World Power Conference, relating to the conference in which the Society has been invited to participate, was noted. The Council voted at its St. Louis meeting to appoint the president in office at the time of the conference to represent the Society. The conference will be held in the United States, Sept. 7 to 12, 1936.

FRIDAY SESSION OF COUNCIL

Resuming its meeting on Friday, the Council considered further matters of general interest, as follows:

USE OF SOCIETY PIN

Recommendations of the Special Committee on the Use of the Society Pin were reported, approved, and adopted. It is hoped to publish these recommendations at an early date.

PAUL DOTY
Gave Charge to New Members

COMMITTEE ON REGISTRATION

By vote of the Council the membership of the Committee on Registration was increased from five to seven, in order that there may be on the committee a representative of each of the seven geographical groups of Local Sections.

PUBLICATIONS

Two matters of business referred by the Local Sections Delegates Conference through the Council to the Committee on Publications, relating to more effective news of Society affairs and the preprinting of technical papers for Society meetings were formally reported by S. W. Dudley, chairman of the committee. No action was taken.

At the suggestion of the Committee on Constitution and By-Laws, H. H. Snelling, chairman, printing of the revised Constitution, By-Laws, and Rules was postponed until revisions in prospect are completed.

ALEX D. BAILEY
Elected Vice-President

1935–1936 COUNCIL

Upon the completion of the business of the 1934–1935 Council, the 1935–1936 Council convened. R. E. Flanders introduced the new members and presented the president's gavel to President W. L. Batt, who took the chair and delivered a brief address. A vote of sincere appreciation for the services of Mr. Flanders as president was recorded.

EXECUTIVE AND OTHER COMMITTEE APPOINTMENTS

President Batt announced the personnel of the Executive Committee of Council, as follows: W. L. Batt, chairman, H. R. Westcott, W. A. Shoudy, J. A. Hall, and J. W. Parker. Appointments by the president to administrative and other committees were announced. In view of the great number of these appointments and of the fact that there will be distributed to members of the Society with the February issue of A.S.M.E. Transactions a supplement containing the complete personnel of all Society offices and committees, the names are omitted from this report.

It was voted to discharge the following committees with assurances of appreciation and thanks for their completed services: Bond Issue, Capital Goods Industries, Honors, and Registration Procedure. With comments on their functions and the progress of the work in which they are engaged, it was voted to continue the following special committees: Board of Review, Manual of Citizenship, Economic Status of the Engineer, Employment, Engineering History, Freeman Scholarship, Junior Participation (left to Executive Committee with power), Manual of Practice, Policies and Budget, Public Affairs, George Washington Bust, and Westinghouse Memorial.

WILLIAM LYLE DUDLEY
Elected Manager

RELATIONS WITH COLLEGES

Student branches of the A.S.M.E. at the following institutions were approved: Duke University, Durham, N. C.; University of New Mexico, Albuquerque, N. Mex.; South Dakota State College, Brookings, S. D.

HOOVER DAM

A letter from W. H. McBryde requesting the Council to take action regarding the restoration of the name "Hoover Dam," to the project now known as "Boulder Dam" was discussed, and referred to President Batt with power.

RECOMMENDATIONS OF LOCAL SECTIONS DELEGATES

Fourteen recommendations were presented to the Council by the Local Sections delegates in the form of a report of their deliberations during the annual meeting. It was voted to receive the report with thanks, to refer the various recommendations to the appropriate committees, and to submit to the Local Sections Conference before its next meeting a communication setting forth the attitude of the Council on matters relating to Society activities referred to in the report.

JOHN A. HUNTER
Elected Vice-President


O. R. WIKANDER
MELVILLE AWARD


S. J. MIKINA
UNIOR AWARD


S. TIMOSHENKO
WARNER MEDAL

Brief mention of some of the recommendations and the committees to which each was referred, in cases in which action was taken, follows:

The request for a positive constitutional provision that there shall be local sections and that each shall have a delegate to a conference or conferences of local sections delegates, with powers and duties defined in the By-Laws, was referred to the Committee on Policies and Budget.

On the request that the president send a letter to A.S.M.E. members explaining the attitude of the Council on the Engineering Index, it was voted that "the Council goes on record as continuing to approve the purposes and ideals of Engineering Index and does not disagree with the policy of its members, being connected with the Index as individuals who have faith in its usefulness to the engineering profession."

The request to change the present six-year Junior membership limit to an age-33 limit in respect to dues was referred to the Committee on Policies and Budget.

On the matter of delinquents and reinstatements to membership, the Council voted that the sections be urged to take the necessary steps to bring back to membership in the Society before 1936 those who are on the "suspended" and "resigned" lists, and that the Board of Review be asked to codify as quickly as possible all Council actions on such lists and to secure the approval therefore from the Executive Committee, so that these actions can be put into effect immediately.

The recommendation that a greater differential be established in the price of publications to members and to nonmembers was referred to the Committee on Publications.

The matter of nonmember affiliates of local sections was referred to the Committee on Local Sections.

COUNCIL REPRESENTATIVES

In accordance with action taken at the St. Louis meeting of Council (see MECHANICAL ENGINEERING, December, 1935, p. 809) President Batt appointed the following council representatives to the districts noted: Group 1, H. R. Westcott; Group 2, W. A. Shoudy; Group 3, R. L. Sackett; Group 4, E. W. O'Brien; Group 5, J. H. Herron; Group 6, A. D. Bailey; and Group 7, J. A. Hunter.

It was suggested that every Local Section place on its mailing list the names of all members of the Council.

APPOINTMENT OF SECRETARY AND TREASURER

C. E. Davies was reappointed secretary, and W. D. Ennis, was appointed treasurer to succeed Erik Oberg, resigned.

ENGINEERING INDEX

The Council voted to confirm the present arrangement by which Mr. Hannum serves both the A.S.M.E. headquarters staff and the Engineering Index, Inc. (the salary is paid by these two bodies on the basis of the proportion of service rendered to each); and to leave this matter for the Secretary to report to the Council when a change in this arrangement seems advisable. It further voted confidence in the Secretary to handle this situation.

ANNUAL BUSINESS MEETING

The Annual Business Meeting of the Society was held in the Engineering Auditorium, Monday, December 2, at 2 p.m., President Flanders presiding. Results of the favorable balloting on constitutional changes relating to membership grades were announced by the secretary.

Reports of the Council and of the administrative and other committees were presented and approved. These reports were available in printed form, and, as previously noted, will be distributed to all members in Section 2 of the January issue of the A.S.M.E. Transactions.

Opportunity was afforded for verbal presentation of five committees, and discussion was invited, as follows: Finance, Walter Rautenstrauch, chairman; Publications, S. W. Dudley, chairman; Engineers' Council for Professional Development, C. F. Hirshfeld, past-chairman; Policies and Budget, H. R. Westcott, chairman; and the American Engineering Council, F. M. Feiker, executive secretary.

The nominations for members of the Nominating Committee for officers for 1935–1936 were read and the nominees elected. The personnel of the Committee is as follows:

GROUP 1: Edwards R. Fish, Hartford, Conn.; Charles M. Allen, Worcester, Mass. (first alternate); George E. Hulse, New Haven, Conn. (second alternate).

GROUP 2: Walter M. Keenan, New York, N. Y.; J. N. Landis, Brooklyn, N. Y. (first alternate); William E. Caldwell, New York, N. Y. (second alternate).

GROUP 3: H. Diederichs, Ithaca, N. Y.; V. M. Palmer, Rochester, N. Y. (first alternate); F. M. Feiker, Washington, D. C. (second alternate).

GROUP 4: R. P. Kolb, Raleigh, N. C.; B. E. Short, Austin, Texas (alternate).

GROUP 5: F. W. Marquis, Columbus, Ohio; George W. Bach, Erie, Pa. (first alternate); L. E. Jermy, Cleveland, Ohio (second alternate).

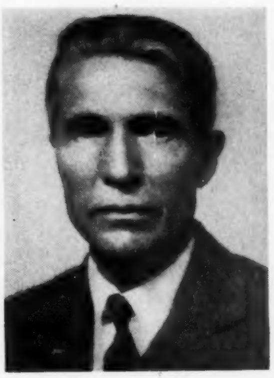
GROUP 6: F. H. Dorner, Milwaukee, Wis.; Robert M. Boyles, St. Louis, Mo. (alternate).

GROUP 7: W. J. Cope, Salt Lake City, Utah.

President Flanders reviewed the Parker litigation, as already recorded in this account under the section devoted to the

C. M. ALLEN
METROPOLITAN-NIGHT SPEAKER

E. E. FREE
SPEAKER AT ANNUAL DINNER



S. MARION TUCKER
ON "TALKING WITH AN AUDIENCE"

Local Sections Delegates, and Mr. Parker was granted the privilege of addressing the meeting.

SOCIAL EVENTS

METROPOLITAN NIGHT

First of the social events was a get-together dinner and party under the auspices of the Metropolitan Section, held at the Roger Smith restaurant on Monday evening. Upward of 300 members and guests attended. C. M. Allen, of Worcester, Mass., delivered his famous, interesting, and spectacular lecture with amazing fire-breathing demonstrations, on "The Use and Abuse of Gasoline, Kerosene, and Other Volatile and Foaming Fluids." Followed a series of games based on indoor athletic sports and skill, which accomplished its purpose of getting members well-acquainted with one another and with the Metropolitan Section. Vincent M. Frost was in charge of the meeting. J. N. Landis is chairman of the Metropolitan Section.

HONORS NIGHT

The Committee on Meetings and Program put into effect a highly commended innovation this year with regard to certain social events. Presidents' Night, formerly held on Tuesday evening, was combined with the Annual Dinner and an Honors Night was planned for Tuesday.

At a dinner to Council members, recipients of honors, the John Fritz Medal Board of Award, and representatives of other Societies was held at the Engineers' Club, at which Ambrose Swasey, honorary member and past-president, and C. F. Scott spoke informally.

The functions carried out at the Engineering Auditorium consisted of the award of Society honors, the presentation to W. F. Durand of the John Fritz Medal for 1935, and the Thurston Lecture, delivered this year by C. H. Purcell, chief engineer, San Francisco-Oakland Bay Bridge, which was a descriptive account of the bridge and engineering problems connected with its construction.

On the platform were the president of the Society, the recipients of honors and their sponsors, the John Fritz Medal Board and its medalist, and the Thurston Lecturer.

The secretary announced the result of the balloting for officers and members of Council for 1935–1936. These results were published in the November, 1935, issue of MECHANICAL ENGINEERING, p. 744, and biographical sketches of the persons elected appeared in the August issue, pp. 527–530. The officers and newly elected Council members are: W. L. Batt, president; Alex D. Bailey, John A. Hunter, R. L. Sackett, and William A. Shoudy, vice-presidents; and William Lyle Dudley, W. C. Lindemann, and James W. Parker, managers.

SOCIETY AWARDS

Society awards presented with appropriate remarks by President Flanders were made as follows:

Student awards to Charles P. Bacha, M.S., Rutgers University, 1935, for his paper "The Behavior of Metals Subjected to Combined Stress," and to Robert W. Beal, Oregon State College, 1936, for his paper "Do Lubricating Oils Wear Out?" introduced by R. C. H. Heck. Mr. Beal was not present.

Charles T. Main award to G. Lowell Williams, Jun. A.S.M.E. graduate, 1935, of Lafayette College, for his paper on "Coordinated Transportation—An Economic Comparison of Railroad, Bus, Truck, Water, and Air Transportation for Long and Short Haul." Introduced by Harte Cooke.

Junior award to Stanley J. Mikina, Jun. A.S.M.E., research engineer, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa., graduate, 1930, of the University of Michigan, for his paper "Effect of Skewing and Pole Spacing on Magnetic Noise in Electrical Machinery." Introduced by G. B. Pegram.

Melville medal to Oscar R. Wikander, Mem. A.S.M.E., mechanical engineer, Ring Spring Department, Edgewater Steel Company, Pittsburgh, Pa., for his paper "Draft-Gear Action in Long Trains." Introduced by L. W. Wallace.

Worcester Reed Warner medal to Stephen Timoshenko, Mem. A.S.M.E., professor of mechanical engineering, University of Michigan, "for his contributions to the theory of the design of elastic structures and the treatment of dynamics of moving machinery." Introduced by Herman Diederichs.

A.S.M.E. medal to Charles T. Main, past-president, A.S.M.E. 1918; president, Charles T. Main, Inc., Boston, Mass., "for distinguished achievements in the textile and other industries and in engineering education, and for eminent service to the engineering profession." Introduced by F. M. Gunby.

JOHN FRITZ MEDAL

In the unavoidable absence of H. P. Charlesworth, chairman for 1935–1936 of the John Fritz Medal Board of Award, Roy V. Wright, past-president, A.S.M.E., and chairman of the 1934–1935 board, took over the duties of presiding officer. Dr. W. F. Durand, honorary member and past-president, A.S.M.E., medalist for 1935, was presented by Dexter S. Kimball, past-president, A.S.M.E., who addressed the chair as follows:

The nineteenth century will no doubt be recorded as the period of man's greatest progress in science, engineering, and industrial development. It produced the telegraph, the telephone, the radio, the gas engine, the airplane, and the electric generator and motor; it developed the steam engine from crude beginnings to the highly developed steam turbine; and it ushered in the Age of Steel. It will also be remembered for its great leaders in science, engineering, and industry, for such a

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distinguished group may never be seen again. High on the roll of honor of those who made the modern steel industry is the name of John Fritz, whose memory is perpetuated by the John Fritz medal awarded annually by the Founders Societies for "notable scientific or industrial achievement." It is eminently fitting that this reward should go to a great scientist and engineer and I have the honor and the pleasure of presenting to you for this award Dr. William Frederick Durand, who is indeed eminent in his profession.

Dr. Durand has had a long and successful career in a wide range of activity. A graduate of the United States Naval Academy, he is one of that group of outstanding engineers that includes Thurston, the first president of the Society, Cooley, Hollis, McFarland, and other graduates of that institution who have contributed much to the high standing of The American Society of Mechanical Engineers. He has seen service in the United States Navy and his services to his country as a scientist during the Great War were noteworthy. He is best known, perhaps, as a successful teacher and consulting engineer and through his contributions to the literature of our profession, which are many and scholarly, particularly in the fields of marine engineering, aeronautics, and hydrodynamics. Few men in the teaching profession or in practice can compare with him for logical and lucid exposition.

Dr. Durand has been honored by appointments to many governmental and scientific commissions, among which the following may be mentioned: Scientific attaché at American Embassy at Paris; member International Commission on Inventions; member President's Aircraft Board; Advisory Board of Engineers, Boulder Dam project; member National Advisory Commission for Aeronautics; member National Research Council; chairman World Power Conference, and many others of similar nature.

He has been honored by election to many learned societies and organizations, including the National Academy of Sciences, the American Philosophical Society, The American Society of Mechanical Engineers, the American Institute of Electrical Engineers, Société Technique Maritime, life member and gold medalist of the American Society of Naval Engineers, Fellow of the American Academy of Arts and Sciences, the American Association for the Advancement of Science, Royal Aeronautical Society, and others.

Lastly, as a man he has lived up to the highest standards of our profession and is loved and admired by all who know him. Surely here is a man whom we all delight to honor and it is my high privilege to present to you Dr. William Frederick Durand for the highest honor in the gift of the engineering profession, the John Fritz Medal.

To the enthusiastic applause which greeted the presentation of the award by Mr. Wright, Doctor Durand responded in his usual felicitous and polished manner.

THURSTON LECTURE

After an intermission in which time was offered for the dignitaries on the platform to take seats in the audience, during which a musical program was rendered, Charles H. Purcell delivered the Thurston Lecture, text of which will be found elsewhere in this issue.

The Robert Henry Thurston Lecture was established by the A.S.M.E. as a tribute to Dr. Thurston, first president of the Society and for years its inspirational leader. These lectures, given before members of the Society at its Annual Meetings, deal with subjects in the zone between engineering and science and present the latest knowledge in the field in which Dr. Thurston was so notable a pioneer. The lecture by Mr. Purcell is the seventh to be presented.

ANNUAL DINNER AND PRESIDENTS' RECEPTION

At the Hotel Astor, traditional scene of A.S.M.E. annual dinners, the 1935 Annual Dinner was held on Wednesday evening, December 3. The switching of the Presidents' Reception, formerly held on Tuesday evening, to this occasion proved a successful innovation, and provided a social interim between the after-dinner speeches and the dancing which concluded the program. More than six hundred members and guests were present, and on the speakers' dais was a notable array of past-presidents and officers of other societies, in addition to those participating in the after-dinner program.

Following the dinner, Robert L. Sackett, Dean, College of Engineering, Pennsylvania State College, vice-president, A.S.M.E., rapped for attention in his capacity of toastmaster and extended a word of welcome. Secretary Davies then announced the total number of new members (2222) added to the rolls since last year's meeting and called upon the representatives who were present to rise. Paul Doty, past-president, A.S.M.E., delivered the "charge to new members," in which he reminded them that they had been elected because of qualifications of character, integrity, and ability as engineers; and because of fitness to discharge the duties of membership they were commissioned to carry on the work of the Society, to cherish its ideals, and to enjoy its honors and awards. He recalled to them that part of these duties was to contribute their engineering talents to the peace, happiness, and security of social life. This they could do, he said, through cooperation with fellow members in the exchange of ideas and recitals of experience with mutual advantages. It was further their opportunity, he continued, to supply special knowledge, skill, and training for the use and benefits of mankind. The engineer, he asserted in closing, believes that practice takes precedence over hypothesis in establishing theory, whether for machines or for men.

This was followed by the reading of the names of fifty-year members, six in number: Charles S. Beach, Morgan Brooks, Edgar C. Felton, Charles T. Main, William N. Rumely, and Charles W. Whiting. Of these, those who were present received fifty-year badges. The others will be presented with similar badges through their individual local sections.

"New Pioneers on a New Frontier," was the title of the address delivered by President Flanders, which also was designated the Henry R. Towne lecture. This thoughtful

presentation of the essence of Mr. Flanders' thinking on the relations of business and government was received with the heartiest applause, and commended to all hearers for thoughtful consideration and study by the toastmaster. The address in full will be found in this issue of MECHANICAL ENGINEERING as the leading article.

The second speaker was E. E. Free, of New York, whose work and studies in noise and smoke abatement are well known and gave special authority to his interesting talk on "Thunder and Smoke."

Dr. Free got his audience in an agreeable and receptive mood by showing a noise meter which he had caused to be concealed in the banquet hall and with which there had been recorded the intensities of such sounds as accompanied the eating of soup and turkey, the playing of the orchestra, the rattle of dishes, and the general hubbub of conversation. These he announced in the decibel scale, which he also explained in simple terms.

He called attention to the fact that the A.S.M.E. had set up the first technical committee for noise abatement, and that an A.S.M.E. member, Ernest H. Peabody, better known for his contributions to the burning of fuel oil and the manufacture of fuel-oil burners, had organized in New York City the League for Less Noise, which was cooperating with Mayor LaGuardia's campaign along this line. He spoke also of the engineer's opportunity to make active contributions to the deadening of needless noises by giving attention to this subject in the design, construction, and operation of machines, which were in his particular province.

Turning to the subject of smoke abatement, Dr. Free exhibited and explained briefly the smoke indicator, and announced that an analysis of the air of the banquet hall, made during the dinner, showed a concentration of about 100,000 dust particles per cubic foot of air, a normal amount for New York City air. He told how the smoke indicator was used not only to measure smoke but to trace to their sources certain characteristic particles. By such means, he reminded his hearers, it would be established that the large power plants were not the worst offenders, office buildings, apartments, and individual home fires contributing by far the greatest amount to this nuisance.

President-Elect Batt was then presented to the audience amid sustained applause and spoke briefly of his appreciation of the honor done him and of his desire to work constructively during the coming year for the advancement of the Society and a coordinated profession.

Adjournment was then made to the Laurel Room, where President and Mrs. Flanders, President-Elect and Mrs. Batt, and Secretary and Mrs. Davies received. Dancing followed the reception.

WOMEN'S PROGRAM

As usual, the women accompanying members of the A.S.M.E. to the Annual Meeting were provided with a full and interesting program to engage their attention while the men were concerned with technical sessions and committee meetings. The women were, of course, invited to all sessions in which they might be interested, and participated in the ceremonies of Honors' Night, and the festivities of the Annual Dinner and Presidents' Reception.

The special program for the women began with a dinner on Monday evening at the Engineering Woman's Club. For Tuesday a series of excursions had been arranged, including visits to the Cloisters, and to a drill at the Fireman's Academy. Luncheon on Tuesday included the Annual Business Meeting of the Women's Auxiliary of the A.S.M.E. and was held at

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the Hotel Commodore. The speaker at the luncheon was Mrs. Harvey N. Davis, whose subject, for which her special training and studies preeminently fitted her, was "The Work of Women With the League of Nations."

On Wednesday morning alternative excursions to the New York Hospital and the Brillo Manufacturing Company, Brooklyn, were provided. Luncheon was served at the Swedish Engineers Club, Stockholm Restaurant. The afternoon was devoted to trips to the Museum of Natural History and to the Hayden Planetarium, located on the Museum grounds.

Further excursions on Thursday morning presented the possibilities of visiting the Bell Telephone Laboratories or "The House of the Future," at Rockefeller Center. The Annual Tea was held on Thursday afternoon at the Woman's Engineering Club.

EXCURSIONS

As usual, a varied program of excursions to local plants and points of interest was provided for visiting members who look to the occasion of the Annual Meeting for an opportunity to see something of New York and its environs. Among the excursions offered this year were: Radio City Music Hall; T. E. S. *Peten*, of the United Fruit Company; East River Generating Station, N. Y. Edison Co.; Jacob Ruppert Brewery; Pullman Laundry; Thirty Ninth Street Tunnel (under construction) of the Port of New York Authority; S. S. *Santa Elena*, of the Grace Line; American Sugar Refining Company; Columbia Presbyterian Medical Center; Hayden Planetarium of the Museum of Natural History; Ford Motor Plant at Edgewater, N. J.; New York Telephone Company; Stevens Institute of Technology, Hoboken, N. J.; Hunts Point Coke and Gas Plant of the Consolidated Gas Company of New York; Schock, Gusmer and Company, Inc., Hoboken, N. J.; and Protexol Corporation, Kenilworth, N. J.

RELATIONS WITH COLLEGES

The Committee on Relations With Colleges revamped its habits of the last several years and devoted the morning and afternoon of Wednesday to student-branch affairs. In the morning the honorary chairmen met with the committee and discussed details of student-branch administration. There was unanimity of opinion regarding the success of the new student-branch policy, and only minor changes or adjustments were requested. The honorary chairmen received with appreciation news of the new mileage arrangements whereby honorary chairmen will receive five cents per mile one way and the official student delegate also five cents per mile one way for attendance at the annual student meetings held in ten districts throughout the United States.

The Committee on Relations With Colleges invited a large number of prominent engineers to meet at the luncheon with student members. Altogether 125 attended this meeting held at the Hotel Astor and addressed by President Flanders and President-Elect Batt. At this luncheon the winners of the Chas. T. Main and Student Awards were seated at the speaker's table and were introduced to the audience.

TECHNICAL SESSIONS

The technical program of the Annual Meeting was so large that adequate comment on the individual sessions is impossible. The attendance at most of the sessions seemed larger than last year and the discussion was lively. There were changes in the final program which were not included in the announcement of the November issue of MECHANICAL ENGINEERING.

At the machine-shop practice session on Tuesday morning a paper on "Developments in Modern Drop Forging and Their Relation to Current Machine-Shop Practice," by R. E. W. Harrison, replaced the one announced on "Steel-Plate Structures Vs. Cast Iron," by R. T. Hazelton.

In the sugar session, the paper entitled "Observations on the Formation and Growth of Sugar Crystals in Vacuum Pans," by A. L. Webre, was followed by a general discussion of vacuum-pan control. Mr. Webre's paper will appear in an early issue of MECHANICAL ENGINEERING.

In the mechanical-springs session, two additional papers were presented, one on "Double-Action Springs," by J. W. Rockefeller, Jr., and the other on "The Uniform-Section Disk Spring," by J. O. Almen and A. Laszlo.

In the Tuesday afternoon hydraulics session, an additional paper was presented by H. M. Boetcher on "Metallurgical Aspects of Cavitation."

In the session on occupational diseases, a paper entitled "Proposed Fundamental Requirements Relating to the Design of Exhaust Systems—A Preliminary Report," by Theodore Hatch, was added.

In the iron and steel session there was an additional paper on "Recording Extensometer for Rolling Mills," by M. Stone.

From the textile session the discussion on application of printing ink to textile printing was postponed to a future meeting.

For the power session on Wednesday afternoon, Charles E. Lucke prepared a progress report on recent progress in power in which he had the assistance of the Power, Fuels, Oil and Gas Power, and Hydraulics Divisions. This will be published in an early issue of MECHANICAL ENGINEERING.

The papers presented at the session on compensation laws were entitled: "Workmen's Compensation and Social Insurance," by F. Robertson Jones; "New Jersey's Experience With Workers' Compensation Disease Legislation," by Frederick S. Kellogg; and "Occupational Disease in Workers Compensation; Definition and Allied Problems; Controlling Principles," by Austin J. Lilly.

There was a discussion of a new fan test code, by H. F. Hagen, added to the session on fan test codes.

At the fuels session, Thursday morning, the symposium on zoned and metered-air control for underfeed stokers was changed to a paper on that subject by H. E. Macomber and A. S. Griswold.

Scheduled discussions at the wood-industries session were replaced by papers on the following subjects: "Pre-Framing and Treatment of Structural Timbers," by Earl Stimson, and "Machinery for the Pre-Framing of Structural Timbers," by J. F. Seiler.

A paper was added to the boiler-feedwater session entitled "New Laboratory Data Relative to Embrittlement in Steam Boilers," by F. G. Straub and T. A. Bradbury. "The Use of Solubility Data to Control the Deposition of Sodium Sulphate or Its Complex Salts in Boiler Waters," by Schroeder, Berk, and Partridge, was not presented.

An additional session was added to the Thursday afternoon program on the effect of temperature on metals. This session was under the auspices of Joint Research Committee on Effect of Temperature on the Properties of Metals. The papers presented were:

Progress report on cooperative study of a stable 18:8 without stabilizing additions; progress report on seizure of metals at elevated temperatures and methods of testing for propensity toward seizure; "Long-Time Creep Tests of 18 Cr-8 Ni Steel and 0.40 Per Cent Carbon Steel," by H. C. Cross and F. B. Dahle; progress report on short-time tensile tests at 850 F of the 0.40 per cent carbon-steel material K-20; and "High-Temperature Properties of Cast and Wrought Carbon Steel for Large Valves for High-Temperature Service," by H. C. Cross and F. B. Dahle.

The following papers, in photo-offset form, are available and will be sent, as long as the supply lasts, to members requesting them:

"Control of Bearing Pressures in Rolling Mills," by O. S. Peters and F. Buckingham.

"Progress in Railroad Mechanical Engineering," prepared by committee consisting of A. I. Lipetz, W. H. Clegg, and K. F. Nystrom.

"Factors in the Selection of Coal for Underfeed Stokers," by committee representing Appalachian Coals, Inc.

"Ignition and Combustion of Diesel Fuels," by G. D. Boerlage and J. J. Broeze.

"Bearing Investigation by the Varying-Wear Method," by John R. Connelly and Charles C. Hertel.

"Heat-Recovery Design for Petroleum Refineries," by Norman T. Buddine.

"Oil-Engine-Electric Generating Station Operating Costs," by George C. Eaton.

TECHNICAL COMMITTEE MEETINGS

More than the usual interest was shown this year in the technical committee meetings which paralleled the technical sessions. Forty-seven meetings were held: research 16, standards 18, power test codes 7, safety 3, boiler code 2, and A.S.T.M. 1. The total attendance at these meetings was 545.

RESEARCH ACTIVITIES

The week of research-committee meetings opened with that of the standing committee on Tuesday morning. N. E. Funk presided in Chairman Eaton's absence and was later elected to the chairmanship for the coming year. The secretary reported for record that the following five special and joint

research committees were to sponsor technical sessions during the week: Mechanical springs, metal cutting, absorption of radiant heat in boiler furnaces, boiler-feedwater studies, and effect of temperature on the properties of metals. In all 21 reports and related papers were contributed to the Annual Meeting program in this way.

Owing to two resignations due to ill health the committee was required this year to nominate three members for appointment. This obligation has been the subject of correspondence, so after a brief discussion the naming of E. G. Bailey, vice-president of The Babcock and Wilcox Company, James E. Gleason, president of The Gleason Works, and L. W. Wallace, director of equipment research of the Association of American Railroads, was agreed upon. These appointments were later made by President Batt.

Luncheon meetings were held by the committees on metal cutting, metal-cutting fluids, condenser tubes, and absorption of radiant heat in boiler furnaces. Other special and joint research committees which met during the week were those on critical-pressure steam boilers, mechanical springs, metal-cutting materials, effect of temperature on the properties of metals, executive committee on boiler-feedwater studies, thermal properties of steam, metal-cutting data, strength of vessels under external pressure, alkalinity and sulphate relations in boiler-water salines, and fluid meters.

At the meeting of the special research committee on critical-pressure steam boilers it was announced that $1000 had been received from industry during the year to assist in financing the studies on dissociation.

Plans for the reorganization of the special research committee on lubrication were completed at the A.S.M.E. Research Committee meeting. The personnel of this committee will be announced soon.

At the meeting of the fluid meters committee held Friday afternoon, S. R. Beitler, of the department of mechanical engineering, Ohio State University, a member of the committee, presented to it and the Society a 400-page bound copy of the report on orifice coefficients which had been completed during the year by the joint A.G.A.-A.S.M.E. subcommittee. At this meeting also H. S. Bean reported on the plans for the research on flow nozzles, which is soon to be started at the National Bureau of Standards under this committee.

Much interest was shown in the several papers which were presented before the sessions on boiler-feedwater studies, C. H. Fellows, chairman, and the effect of temperature on the properties of metals, H. J. French, chairman.

STANDARDS

The annual meeting of the sectional committee on small tools and machine tool elements, C. W. Spicer, chairman, held on Wednesday afternoon was attended by 26 members. At this meeting reports from its various technical committees were received. At this time also the committee examined the completed draft of the proposed American standard for lathe-spindle noses, approved by Technical Committee No. 4 at its meeting the day before, as well as the draft of the proposed American standard for chucks and chuck jaws recently completed and approved by Technical Committee No. 11. Attention was given also to the report of Technical Committee No. 6 on designations and working ranges of machine tools, copies of which were distributed at the meeting. This report covered the status of this phase of standardization work so far accomplished by the various groups of machine-tool builders. This information had been secured as a result of a questionnaire distributed by Technical Committee No. 6 to the various groups of machine-tool builders.

An important meeting in this group was that of Technical Committee No. 7 on twist-drill sizes, W. C. Mueller, chairman. At this meeting the report on nomenclature for twist drills was approved. For the most part, however, the discussion was devoted to changes in the lengths and the list of preferred diameters selected from existing sizes for inclusion in the revised draft of the proposed American standard for twist drills. For the consideration of the committee at this time copies of the General Motors tentative standard on this subject were distributed. It was decided by those present at the meeting that this further revised draft of the proposed American standard when completed should be again referred to the sectional committee and subsequently to the A.S.A. for approval.

Technical Committee No. 3 on machine tapers, F. S. Blackall, Jr., chairman, held a meeting on December 3 to consider first the report of G. A. Bouvier's subgroup on steep tapers. Following this, final action was taken on the proposed American standard for self-holding machine tapers. With agreement reached on a satisfactory system of numbering for the $^3/_4$-in. taper embodied in this proposal the committee approved the proposed standard for submission to the members of the sectional committee.

Technical Committee No. 17 on nomenclature, O. W. Boston, chairman, made a comprehensive report of its activities at the meeting of the sectional committee on Wednesday afternoon and held a meeting of its own the following morning. Through the activities of this committee all of the standards being developed as a part of this project are provided with adequate and up-to-date definitions of terms.

Nineteen members attended the meeting of the sectional committee on allowances and tolerances for cylindrical parts and limit gages held on Tuesday, December 3. The discussion centered on the report of Subcommittee No. 1, which consisted of a proposed set of ranges and tolerances with the fewest possible and widest practical steps following the general trend of the present American Tentative Standard (B4a) and the I.S.A. standard. The committee decided, however, that to obtain further information on tolerances and allowances in common use, copies of a questionnaire are to be sent to a group of manufacturers in each industry. The information thus obtained will be used to supplement the report of Subcommittee No. 1.

At meetings on Wednesday and Thursday afternoons progress was made toward the standardization of screw-thread gages. At these meetings the report of the special subgroup recently appointed to make a survey of present gaging practice, under the chairmanship of W. L. Barth, was presented and discussed at some length. Later the scope of the subgroup's work was increased and additions were made to its personnel.

The progress reports of the five subcommittees of the sectional committee on surface qualities were presented at the committee's meeting on Thursday morning which was presided over by H. K. Rutherford, chairman. In the discussion which followed it was agreed that separate standards should be developed for the different types of surfaces coming within the scope of the several subcommittees and that Subcommittee No. 5 on ways, means, and apparatus for measuring quality of surface should make the necessary preparations to measure the standard surfaces developed by Subcommittees Nos. 1, 2, and 3. In this connection the chairman was authorized to appoint a subcommittee on finance to secure the funds necessary to cover the cost of these measurements. This meeting was attended by 28 members.

Consideration of certain details not now included in the Code for Pressure Piping occupied the meeting of the special subcommittee on welding of branch connections under the

chairmanship of E. R. Fish on Tuesday morning. An effort was made to arrive at definite rulings on design and construction of welded pipe fittings and attention was given as well to standards of construction for lower temperatures. In addition to the regular members of this subcommittee the meeting was attended by a number of others connected with the industry.

This year 48 attended the standards luncheon which was held on Wednesday. C. W. Spicer, the retiring chairman of the A.S.M.E. Standardization Committee, presided. A meeting of that committee preceded the luncheon at which the appointment of J. E. Lovely, chief engineer, Jones and Lamson Machine Company, Springfield, Vt., to fill out the unexpired term of L. A. Cornelius, resigned, was recommended as well as the appointment of W. C. Mueller, manufacturing planning engineer, Western Electric Company, Chicago, Ill., as the new member of the Standardization Committee. Alfred Iddles, vice-president, United Engineers and Constructors, Inc., Philadelphia, Pa., was elected to the chairmanship.

A preliminary meeting of the mechanical standards committee which is to be advisory to the American Standards Association was held on Wednesday afternoon. When completely organized this advisory committee will consist of official representatives of 20 or more professional societies, trade associations, and government departments having a major interest in the development of standards in the mechanical field.

On Friday the Society acted as host to the American Gage Design Committee of which J. O. Johnson is chairman and H. W. Bearce is secretary.

POWER TEST CODES

Throughout the week seven committee meetings of the power-test-codes group were held. The series was concluded with the meeting of the main committee on Friday morning at which the routine business having to do with the work of the 21 committees of this group occupied most of the time. Progress reports were presented by nine committees which have work under way. W. A. Carter reported on the progress which his special subcommittee, on the measurement of fluid flow, Committee No. 19 on instruments and apparatus, made at its November 5–6, 1935, meeting held in Pittsburgh.

On Wednesday afternoon the subcommittee on fans of which M. C. Stuart is chairman sponsored a technical session, a committee meeting having been held in the morning.

Well-attended committee meetings are reported by Committee No. 4 on stationary steam-generating units, E. R. Fish, chairman; Committee No. 6 on steam turbines, C. H. Berry, chairman; and Committee No. 11 on complete steam-power plants, F. M. Van Deventer, chairman.

As chairman of Committee No. 21 on dust-separating apparatus, M. D. Engle reported a satisfactory meeting of his group on Wednesday, December 4. This committee, which was organized in December, 1934, has been divided into five subcommittees, all of which have been at work throughout the year.

An all-day meeting of Committee No. 18 on hydraulic prime movers took place on Wednesday. E. C. Hutchinson, chairman, reported the completion, except for minor details, of the revision of the Test Code for Hydraulic Prime Movers.

ACCIDENT PREVENTION AND INDUSTRIAL HEALTH

An all-day meeting of the A.S.M.E. Boiler Code Committee was held on December 6, 1935, at which interpretations and revisions of the Code were considered. The committee also considered numerous requests for expressions of opinion on features of code compliance in connection with designs of boilers and their appurtenances.

Two of the 36 technical sessions scheduled during the week of the Annual Meeting were held under the sponsorship of the Safety Committee. Chairman W. M. Graff presided at the session on occupational diseases on Wednesday morning at which the following four papers were read and discussed: "The Additional Responsibility Placed Upon Industry by Recent Occupational-Disease Legislation," by H. D. Sayer; "Engineering Control of Occupational-Disease Hazards," by Warren A. Cook; "The Use and Limitations of Protective Devices and Equipment," by Philip Drinker; and "Some Fundamental Factors in the Design of Exhaust Systems," by Theodore Hatch. The authors of these papers are prominent in this field, Mr. Hatch being the chairman of the subcommittee on fundamentals of the A.S.A. sectional committee on a safety code for exhaust systems. This committee is proposing a rather new approach to the design of exhaust systems, particularly those for the removal of dusts. It is probable that these papers will be published in an early issue of MECHANICAL ENGINEERING.

The session on compensation laws was held in the afternoon of the same day with the Safety Committee acting as co-sponsor with the Management Division of the Society. The three papers which were presented and freely discussed dealt with (1) the present status of workmen's compensation laws, (2) the experience of the State of New Jersey with workmen's compensation laws, and (3) definition, allied problems, and principles of occupational disease in workmen's compensation.

At the annual meeting of the A.S.M.E. Safety Committee Wesley M. Graff was re-elected to the chairmanship of the committee. Dan L. Royer, chief engineer of the engineering department of The Ocean Accident and Guarantee Corporation, Limited, New York, N. Y., was appointed by President Batt as the new member of the committee to serve for five years.

A meeting of the sectional committee on a safety code for mechanical power transmission was held on Friday morning. Chairman C. B. Auel had called this meeting to review the text of the present American standard code, published in 1927, to determine the necessary changes and additions, and to incorporate requirements for mechanical power control.

ANNUAL MEETING COMMITTEES

Credit for the success of the Annual Meeting must be given to the numerous committees of the Society who arranged the technical papers and general events, and to the authors and individuals who presented papers, took part in the discussion, and provided in hundreds of ways for the enjoyment and profit of all who were in attendance.

All meetings of the Society are under direct supervision of the Committee on Meetings and Program, the personnel of which is as follows: R. I. Rees, chairman, E. C. Hutchinson, H. N. Davis, Clarke Freeman, and R. F. Gagg.

Special committees directly responsible for many factors entering into the success of the meeting were as follows: Dinner and Reception, R. V. Wright, chairman, C. E. Brune, W. T. Conlon, Lillian M. Gilbreth, G. W. Kelsey, C. W. Parsons, J. W. Roe, and F. A. Scheffler; Excursions, Charles Peace, chairman, F. E. Brooks, N. S. Brown, E. E. Charleton, Frank Cooney, T. F. DuPuy, J. C. Faulkner, F. M. Gibson, E. Koch, and F. A. Thoene; Honors Night, C. P. Bliss, chairman, K. H. Condit, S. W. Dudley, R. F. Gagg, and J. W. Parker; and the Women's Committee, Mrs. Arthur Bruckner, chairman, Mrs. W. S. Huson, registration, Mrs. A. M. Feldman; Excursions, Mrs. Leo Geenens, luncheon, Mrs. R. V. Wright, annual dinner, Mrs. C. B. LePage and Mrs. A. J. Herschmann, annual tea, and Miss Burtie Harr, publicity.

ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

AERONAUTICS

New Form of Biplane

EXPERIMENTS with a single half-wing led to the conclusion that certain departures from the conventional arrangement of the wings of a biplane would improve its stability in the neighborhood of stalling incidence and give a slight increase of maximum lift. Actually, not only was the stall delayed and maximum lift somewhat increased, but the optimum lift-draft ratio compared well with that of an ordinary biplane when allowance was made for difference in aspect ratio and mean gap. Tests on a rolling balance showed that the new biplane was stable in roll for incidences up to 40 deg and beyond, indicating that a machine built on these lines would exhibit reluctance to enter a spin. At the higher incidences the modified arrangement gave lower values of lift-drag ratio than the ordinary biplane, a result which, while offering the practical advantage of allowing a steeper gliding angle at landing, indicates the occurrence of partial and premature stall at some parts of the wings, especially when taken in conjunction with the fact that backward movement of the center of pressure began at about 8 deg incidence, which is a lower angle than usual. In order to investigate the onset of the stall, observations were made on streamers of wool attached to the upper surfaces of the wings as the latter, mounted in the wind tunnel, were altered as regards incidence.

Data of tests with this biplane are given in the original article.

A complete biplane cellule embodying apparently the best wing arrangement was exhaustively tested and this substantiated the half-wing test results.

Within the limits of these experiments it appears that the new biplane arrangement leads to stability in roll and less diminution of aileron control at large angles of incidence, together with some gain in maximum lift with no apparent sacrifice of other qualities; and the possibility of connecting the wings rigidly together near the tips is an advantage which may compensate for structural difficulties in other respects. With this aspect in view, similar experiments are in progress on R.A.F. 38 wings, which, being of thicker section than R.A.F. 15, are better suited to the construction of the upper, sharply tapered, wing.

One outcome of the tests on airfoils carried out in the compressed-air tunnel has been to emphasize the importance of smooth surfaces in reducing resistance at high speeds of flight. It is now possible to specify numerically the smoothness of a surface finish beyond which no further appreciable reduction of drag can be achieved, and it has been proved that at speeds above 200 mph asperities exceeding about one-thousandth of an inch must be avoided on the wings and body of a really efficient airplane. It appears, therefore, that the doped fabric finish of many machines is by no means smooth enough, and that surfaces as smooth as rolled aluminum sheet are requisite for first-class performance. (From a report of the Aerodynamics Department of the National Physical Laboratory, abstracted in part in *Engineering*, vol. 140, no. 3639, Oct. 11, 1935, p. 382, 3 figs.)

ENGINEERING MATERIALS

Pumice

PUMICE has been employed in construction to a small extent in localities where it was found. It is chiefly used, however, for polishing. In Europe it is found principally in the Lipari Islands where it is encountered in the form of small lumps of different shapes and dimensions. Geologically it belongs to the classification of volcanic rocks, the family of trachytes. As a material of construction it has the following advantages: A cubic meter of pumice weighs only from 600 to 650 kg; it provides a sound insulation eight times as great as that of ordinary brick; its coefficient of heat conductivity is 0.20 as compared with 0.70 of ordinary brick; tensile strength is 100 kg per sq cm; among its other advantages are the facts that pumice is not attacked by acids, is not affected by heat except by very high temperatures, and has a very low power of absorbing water. Pumice stone can be sawed like wood.

The average analysis of Lipari pumice in percentages is, as follows: Silica 70.00; alumina 15.80; oxide of iron 3.50; potash and soda 6.50; lime and magnesia 1.90; water 3.20.

As an illustration of the increasing use of pumice brick, the author cites two large installations where this is done—one being a group of low-cost houses and the other a 20-story skyscraper at Turin, Italy. (V. Charrin in *Revue des Matériaux de Construction et de Travaux Publics*, no. 305, February, 1935, pp. 45–46)

Superpure Aluminum

IT IS stated that a commercial process for manufacturing aluminum of purity 99.99 per cent or better has been developed by the d'Alais, Froges et Camargere Co., France. The standard process for manufacturing aluminum using a cryolite bath can give at best only 99.6 per cent purity, the principal impurities being iron and silicon.

Better results were obtained in the Betts process of electrolytic refining in which the anode consisted of aluminum and a heavy metal. The electrolyte was heavier than aluminum and lighter than the anode alloy and a cathode bath of pure aluminum was used. When the electric current was sent through the bath the aluminum was carried over from the anode to the cathode, while the impurities remained in the anodic alloy. In 1922 Hoopes obtained aluminum of a purity 99.9 using the three-layer process, the electrolyte being a solution of alumina in a molten mixture of cryolite and barium fluoride. In the new process the same three-layer principle has been employed, the electrolyte being a mixture of aluminum fluoride, sodium fluoride, and barium chloride. The anode alloy contains aluminum and 33 per cent copper. The best sample contains as high as 99.998 per cent aluminum, 99.99 per cent being, however, the standard product.

There is a great difference between this new superfine metal and the commercial article. It is materially softer than ordinary aluminum, a better conductor of electricity, and can better withstand corrosive effects. Among other things,

it has an extraordinary resistance to acid and alkaline chemical reagents, and to atmospheric and sea-water corrosion. All of these statements are supported by test data presented in the original article.

Among the possible fields where the new material can be employed is mentioned the manufacture of foil for wrapping cheese, tests having shown that Gruyère cheese does not blacken after three months' use as it does in tin. It can also be used for electrolytic conductors and interrupters. (*Schweizer Archiv.*, vol. 1, no. 8, August, 1935, pp. 145–148, 2 figs.)

FUELS AND FIRING

Burning Bituminous Coal and Low-Temperature Coke Breeze in a Grinding Furnace

IN 1933 a German concern received an order for the reconstruction of a boiler plant having an inclined-type waterwall boiler built in 1924 which was to be preserved. Furthermore, because of its availability in the neighborhood of the plant it was required that the furnace should burn fine bituminous coal and low-temperature-carbonization coke breeze. It was decided to install a Krämer grinding furnace, the general layout being shown in Fig. 1, where *a* is the side of the cooled furnace wall, *b* the rear cooled furnace wall, *c* the air preheater, *d* the combustion-air blower, *e* the secondary grate, *f* the hot-air conduit to the pulverizer, *g* the drier, *h* the fuel supply, and *i* the combustion-air ducts.

The dimensions of the various parts are given in a table in the original article. The blower heating surface is 218.28 sq m. The cooling surface in the furnace is 57.80 sq m, making a total evaporating and heating area of 276.08 sq m. The heating surface of the superheater is 67.8 sq m, and the volume of the furnace 42 cu m. The surface of the air preheater is 140 sq m and the power consumption of the blower 11 hp. The plant was installed in the first half of 1934 and at first gave no little trouble in the matter of ash removal. Shortly after the plant was put into operation, the secondary grate was found to be covered with lumps of coarse coke and ashes. This was due to insufficiency of the grinding in the mill and an excessively short drier shaft as a result of which large pieces of fuel were carried over onto the grate. The grates were so caked that the flow of combustion air was interfered with and there was difficulty in removing this caked material from the shaft. The grinding mill was then removed to the ash cellar, as shown in Fig. 1, which rapidly eliminated the previous defects, gave a good grinding, and obviated the carryover of coarse fuel particles to the furnace.

The remainder of the article gives details of tests with Saxon bituminous coal and low-temperature-carbonization coke. It is stated that in all cases the deposits of slags and fly ash were surprisingly

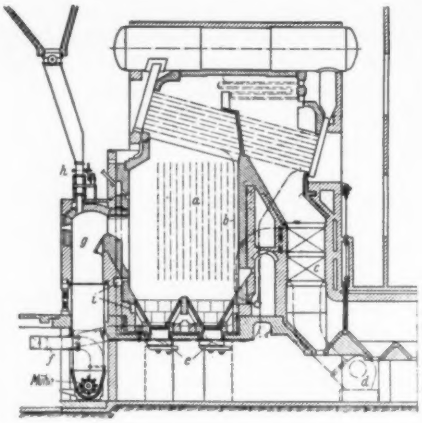


FIG. 1 INCLINED-TYPE WATERWALL BOILER WITH KRAMER PULVERIZING FURNACE

small and in the worst case did not exceed 4 per cent of the fuel burned. The ash was so fine that it could not be seen in the smokestack gases and so light that it was carried far away and showed no deposits in the vicinity of the plant. The fly ash was light gray in color, particularly light in the case of low-temperature-carbonization coke.

The plant is said to be easily subject to regulation. Where the variations of load are comparatively small it is merely necessary to vary accordingly the supply of fuel, which can be done by infinite steps through the variation in the revolutions of a collector motor. When the changes in load were great it became necessary to vary the amount of air supply to the grinding mill. The smokestack damper was adjusted only infrequently, but less than in other grate plants. Changes in load could be controlled within wide limits as shown, for example, in a diagram showing a sudden change of from 11 to 4.5 tons per hr, which was done without material deterioration of output as indicated by the CO_2 content in the smokestack gases and without blowing the safety valve. The details of the construction of the Krämer furnace are not given. (Carl Heinrich in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 79, no. 10, March 9, 1935, 329–331, 3 figs.)

HYDRAULICS

Simple Graphical Solution for Pressure Rise in Pipes and Pump-Discharge Lines

THIS paper, of a mathematical character not subject to abstracting, was briefly summarized by E. B. Strowger in the discussion which followed its presentation. He said that Professor Angus had presented the graphical method of water-hammer computation in a manner which makes it quite simple, and the numerous applications given add to the usefulness of the paper. He first develops the pressure-wave curves for a simple pipe by referring to Joukovsky and to the "arithmetic integration" method of computing, published by N. R. Gibson, and then introduces the Allievi equations by considering the summation of the upward-traveling direct waves and the downward-traveling indirect waves. The method of simultaneous equations is then developed and the graphical method follows. This is a logical method of development and it is interesting to find that arithmetic integration computations are used in developing the proper concepts of the problem. Mr. Strowger has taken exactly the same method in analyzing the five Allievi equations given in Halmos' abstract of the 1902 Allievi paper before finally deriving them by a rigorous method.

Professor Angus points out that Allievi's book on water hammer is not often read by engineers, because of its mathematical character, and that the entire mathematical difficulty in the work is due to two equations established by Allievi from hydrodynamics. The author proceeds then to the explanation of these equations.

The author states the equations and then says that if the reader will take the trouble to draw actually the complete set of pressure diagrams as the author shows how, and carry out the calculation by arithmetic integration, he will be convinced of the accuracy of the Allievi equations. One of these equations (there are actually *three* of them) applies only to pressure rise at the ends of two successive intervals, while two which are best known apply to any point of the pipe at the reservoir and in other places.

Furthermore, the author establishes four equations of a comparatively simple kind, which, together with the fifth equation, which latter establishes a connection between the law of gate motion, the head H, and velocity v, are sufficient to solve all problems. From this the

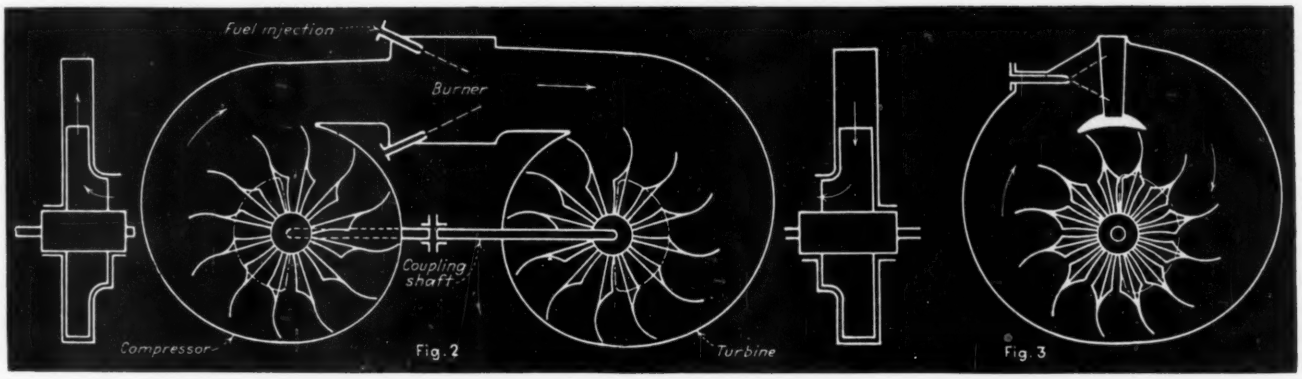


FIG. 2 PRINCIPLE OF TRUMPLER TURBINE

FIG. 3 CROSS SECTION OF SINGLE-WHEEL UNIT

author proceeds to the development of graphical constructions for the solution of these problems. He next shows how his method may be applied to the solution of problems dealing with gate closure, gate opening from closed gate, gate opening from part gate, resonance, simple surge tank, and pump-discharge lines. (Robt. W. Angus, University of Toronto, in *The Engineering Journal*, vol. 18, no. 2, February, 1935, pp. 72–81, 13 figs. for the original article, and discussion in no. 5, May, 1935, pp. 264–273, 18 figs.)

INTERNAL-COMBUSTION ENGINEERING

Blower-Scavenging Diesel Engine

ONE of the most interesting engines exhibited at the Shipping, Engineering, and Machinery Exhibition at Olympia, London, is a new Diesel model with blower scavenging, shown by Petters, Limited, of Yeovil. This engine is not intended to replace their well-known standard crankcase-scavenge models, but is produced to meet the demand the makers have found to exist for a positively scavenged unit where their standard Diesel engine is not suitable. An important field for which the engine can be employed with advantage is that of driving marine auxiliaries, and it has also been developed with a view to its application for propulsion units. The new unit is to be produced in 2-, 4-, 5-, and 6-cylinder models, having powers from 110 to 330 bhp, that is, 55 bhp per cylinder. This power is developed at a speed of 500 rpm. A fuel consumption of 0.39 lb per bhp-hr has already been secured, and the makers are convinced that a still better figure will be obtained in the future. The lubricating-oil consumption is about 1 per cent of the full-load fuel consumption. (*Engineering*, vol. 140, no. 3636, Sept. 20, 1935, p. 299)

Trumpler Internal-Combustion Turbine

AN illustration in the original article shows a small experimental machine which has operated successfully. This turbine is essentially a continuous-cycle, constant-pressure type wherein compression and expansion are performed by a single wheel. The compressor volute, Figs. 2 and 3, surrounds only half of the periphery of the impeller, leaving the other half inactive. However, the turbine segments may be thought of as inserted into the inactive compressor half. In that case, a single wheel with approximately radial blades is working at opposite sides of the casing circumference as compressor and turbine. Each blade travels with every revolution through a cool compressor section and the hot turbine part. Heating and cooling follow in such rapid succession that the blade material assumes an average temperature. By careful design the hot turbine-casing half can be separated sufficiently from the cool compressor segment to keep the heat flow small, and no water cooling is required.

In the model described in the original article city gas is used as a fuel and it is said that even at the low speed of 4500 rpm, where thermal efficiency is less than 1 per cent, the hydraulic performance is satisfactory. At 15,000 rpm, thermal efficiency would be over 10 per cent. (Wm. E. Trumpler in *Power*, vol. 79, no. 10, October, 1935, p. 532, 3 figs.)

Clerget Airplane Oil Engine

THIS engine of 500 bhp was recently tried in an airplane. Figures for fuel consumption show that with oil it had a radius from 25 to 40 per cent greater than with gasoline. The actual consumption was 166 grams per bhp-hr, and the fuel employed was gas oil with the specific gravity of 0.86.

The engine runs at 1850 rpm and has 14 cylinders arranged in double-star form, with two superimposed ranges of seven cylinders each. The aggregate capacity is 34 liters, and the engine is of the four-stroke type with air cooling. The weight without propeller, but including the entire equipment and the compressed-air starters, is 600 kg, or 1.2 kg per bhp.

The bore of the cylinders is 140 mm, the piston stroke 160 mm, and the compression pressure 14.5 kg per sq cm.

The third engine of the type now being constructed is to be fitted with a supercharger. The engine is air cooled and the inlet and exhaust valves are inclined at an angle of about 60 deg to the horizontal and are disposed symmetrically on each side of the central fuel valve. There is a fuel pump in front of each cylinder with a short pipe to the fuel valve. All the pipes are equally long. The fuel pumps are arranged for double injection. The details of the various types of airplane oil engines are given in a table in the original article. (*Oil Engine*, vol. 3, no. 27, Mid-July, 1935, pp. 74–75, 1 fig.)

MACHINE PARTS

Wearn's Autoflex Drive

THE autoflex drive enables short belt centers to be used, includes a clutch operated by a lever, and provides for automatic belt tensioning, which is said to give smooth drive take-up and reduced belt wear. The operating principle is the epicyclic train. The driven pulley rotates a pinion through a small clutch. The pinion engages with a sun wheel keyed to the machine shaft, the pinion thus becoming a planetary. Pinion and pulley with their shaft are hung on the machine shaft so that they are free to rotate around the sun wheel. The belt prevents this rotation, but when the machine is standing the belt is slack

enough to give "full slip," only the pulley weight providing tension. When the motor starts the take-up is gradual, because the pinion rotates without driving the machine. Instead, the pinion climbs round the sun wheel, taking with it the driven pulley until the belt tension has become equal to the torque required to start the machine, when the pinion is held, and instead of climbing, it rotates the sun wheel and thus drives the machine. As the torque required is reduced the tension on the belt is relaxed in proportion, the belt tension always equaling the torque on the pinion.

It is said that in tests at the National Physical Laboratory this drive over a period of 100 hr of actual running maintained an efficiency fairly constantly at 90 per cent when the gear was cold and 94½ per cent when the gear was warm. (Serial article describing the Shipping, Engineering, and Machinery Exhibition at Olympia, *The Engineer*, vol. 160, no. 4161, Oct. 11, 1935, p. 371, 1 fig.)

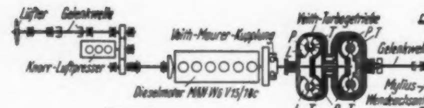


Fig. 4

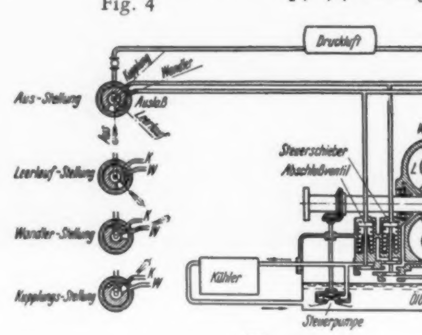


Fig. 5

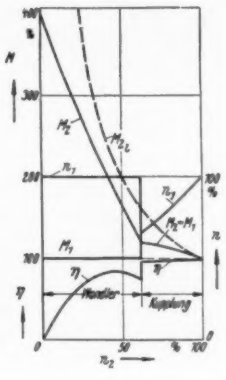


Fig. 6

FIG. 4 LAYOUT OF A DIESEL HYDRAULIC DRIVE FOR A 200-HP CAR, GERMAN RAILWAYS

(*Lüfter* = ventilator; *Gelenkwelle* = flexible shaft; *Knorr-Lüftpresser* = Knorr air compressor; *Dieselmotor MAN* = MAN Diesel motor; *Voith-Maurer Kupplung* = Voith-Maurer coupler; *Voith-Turbogetriebe* = Voith turbo drive; *Mylius-Wendeachsantrieb* = Mylius axle drive.)

FIG. 5 VOITH HYDRAULIC DRIVE FOR RAILWAY CARS

(*Aus-Stellung* = cut-out position; *Leerlauf-Stellung* = no-load position; *Wandler-Stellung* = torque-converter position; *Kupplungs-Stellung* = coupler position; *Kupplung* = coupling; *Wandler* = converter; *Auslass* = exhaust; *Leerlauf* = no load; *Druckluft* = compressed air; *Absperrhahn* = shut-off cock; *Steuerschieber* = control valve; *Abschlussventil* = cut-out valve; *Kühler* = cooler; *Steuerpumpe* = control pump; *Ölbehälter* = oil container; *Abschluss-Stellung* = cut-out position.)

FIG. 6 CHARACTERISTIC CURVES OF A HYDRAULIC DRIVE CONSISTING OF A CONVERTER AND COUPLER

(*Wandler* = torque converter; *Kupplung* = coupler.)

Fluid Drives on Cars Driven by Internal-Combustion Motors

THE author is dealing exclusively with railroad cars and states that in the last few months several cars driven by internal-combustion engines and equipped with hydrodynamic drives for power transmission have been installed on the German Railway System. Unlike the hydrostatic drives which have been tried experimentally on railroad cars and equipped with reciprocating piston pumps and reciprocating piston motors, the hydrodynamic drives employ for the transmission of torque the "mass forces" of a liquid. Hydrostatic drives hitherto have not proved to be much of a success because they are comparatively complicated and difficult to build. On the other hand, hydrodynamic drives seem to be making considerable progress. From this the author proceeds to an explanation of the theory of hydrodynamic drives, which is fairly well known generally.

He proceeds next to describe the Voith turbo drive adopted by the railroads for their 200-hp cars. Fig. 4 shows diagrammatically the layout of such a Diesel hydraulic drive. In this illustration L is the guide wheel, P the pump, and T the turbine. The design shown in Fig. 5 consists of a liquid torque converter and a liquid coupling. The oil tank is located above everything. When both the converter and the coupling are running at no load, the motor is not connected with the driving shaft. The operating liquid is then completely confined to the separate container and the cutout valve is closed. If this valve is opened the liquid is delivered by a little control pump driven from the primary shaft to a converter slide valve and in accordance with the position of this valve the liquid may go either to the converter or to the coupling, and either of the circuits may be used for the power transmission. The operating liquid can go back to the container from either of the circuits which thus become empty when the access of liquid to them is cut off. However, if the control slide valve is in a position to deliver the liquid to the converter the coupling becomes automatically void and vice versa. The losses that result from the transformation of energy, particularly in the converter circuit, reappear in the form of heat, which is mostly taken up by the operating liquid. To take care of this, part of the liquid manipulated by the control pump is passed through a cooler and goes thence into the container. In order to make it possible to start quickly, particularly when the shift is made from coupling to torque converter and when the train strikes the beginning of a grade, it is important that the circuits become filled with oil and emptied very fast.

The operation of the shutoff valve, which makes it possible to cut in or out the entire operating mechanism, is controlled manually by the driver, but can be handled by mechanism automatically. This control is simple and therefore reliable in this case as only one or two valves in two positions have to be operated, otherwise the speed of the car is controlled by varying the output of the Diesel engine.

The characteristic curves of torque and efficiency of such a turbo drive are given in Fig. 6. The drive consists here of a torque converter and coupling. If at full load of the combustion motor the torque is on the primary shaft M_1 and its speed is n_1, then the moment M_2 that is provided by the secondary shaft is dependent on the speed n_2 of the latter. For purposes of comparison there is plotted in Fig. 6 the ideal secondary moment M_2i, it being supposed that the efficiency of the drive is unity and the factor of utilization is also unity. A series of curves in the original article is intended to compare the output capabilities of the turbo drive on one hand and other methods of transmission on the other hand.

In the Trilok drive, installed experimentally on a car by the German Railways, the converter and coupler are combined in a single liquid circuit, one of the blade wheels changing its operative capacity, and acting first as a guide wheel

and next as a rotor wheel. This mode of operation requires that the guide wheel be either stationary or coupled to the driving shaft. The change is effected automatically at the right instant by means of differential torque acting on the variable blade wheel. (Kurt Friedrich in *Zeitschrift des Vereines deutscher Ingenieure*, vol. 79, no. 42, Oct. 19, 1935, pp. 1283–1287, 12 figs.)

MACHINE-SHOP PRACTICE

Cutters for Milling Helicoids

IN Progress Report No. 3 of the A.S.M.E. Special Research Committee on Worm Gears Earle Buckingham showed how the shape of a milled helicoid changes with change in diameter of conical generating cutters or grinding wheels. The present treatment outlines one method of determining the meridian sections of milling cutters or of grinding wheels to produce helicoids of preassigned shapes.

Conditions determining a helicoid are its lead and the shape and position of the generatrix with respect to its axis. A transverse section of a helicoid ensues from screwing the generatrix through a plane normal to the axis, the section curve being the locus of penetration. Expressions for coordinates for any such intersection point yield the equation of the transverse section. This, in conjunction with the lead, equally specifies the helicoid. Certain dangers against which it is necessary to guard are pointed out in the original article. (*American Machinist*, vol. 79, no. 13, June 19, 1935, pp. 454–455)

METALLURGY

Aluminum Cast Irons

MARCEL PLOYE, engineer of the university known as Conservatory of Arts and Crafts, found that small additions of aluminum between 0.02 and 0.5 per cent have no appreciable influence on well-made gray irons free from cementite. They have, however, an important bearing on the behavior of irons poorly made or oxidized, as by deoxidizing them, the additions of aluminum improve greatly their mechanical properties. Nevertheless, they cannot be considered as a complete remedy, since a part of the alumina so formed remains in the metal and constitutes a source of its weakness. An oxidized cast iron later treated by small additions of aluminum is always inferior to an iron of the same chemical composition obtained directly without oxidation.

Additions of aluminum from 0.5 to 18 per cent have also been studied, with the aluminum introduced into the metal in the form of an alloy known as "sifal" containing 94.17 per cent of aluminum, 2.69 iron, and the rest silicon. These tests have shown that the graphitizing action of aluminum is irregular. Up to 8 per cent it is inferior to that of silicon and diminishes to such a point that when the content of aluminum is between 8 and 15 per cent the graphite disappears completely only to reappear with a still higher content of aluminum. It is only when aluminum is below 2 per cent that it improves the mechanical properties of the iron. From 2 to 18 per cent it increases its resistance to oxidation when hot. From 2 to 15 per cent it increases its resistance to corrosion by saline agents, such as sea fogs, and immersion in sea water. (Paper by Marcel Ploye, before the Foundry Technical Association, read March 20, 1935, abstracted from an article by G. d'Ardigny in *La Revue la Fonderie Moderne*, vol. 29, May 10, 1935, pp. 157–158)

Suggestions for Research on Steel Castings

RESEARCH carried out with a view to systematizing the method of feeding and arrangements of heads might well be undertaken, for there is no reason whatsoever why, if the conditions advocated could be complied with and given good metal and molding, a satisfactory casting should not always result.

The discovery of an element which, when added to steel, would reduce the fluid-solid contraction, would be invaluable, and this might well be made the subject of investigation. As yet there are very few data on this question, or how such contraction is affected by added elements. Heated molds supply no solution, for whatever temperature a mold be heated to, the steel will solidify at the same temperature or over the same range of temperature irrespective of the temperature of the mold. The rate of cooling of a liquid or of a solid can be reduced, but the control of the rate of solidification where the range is not narrow is a physical impossibility.

The author recommends research in the formation of blowholes arising from the mold in the case of green-sand casting.

A carbon steel containing less than 0.7 per cent of carbon begins to solidify with the deposition of almost carbonless iron, the carbon-rich material not solidifying until later. Thus, every steel casting is heterogeneous even at temperatures just below the solidification temperature, and will remain so down to atmospheric temperature. It is, therefore, necessary to normalize a steel casting, not only to remove casting stresses, but to bring about a greater uniformity of structure. A correctly heat-treated casting may give tests equal to the same material in a forged condition. Thus, it is possible that castings which can be heat-treated might readily replace the more costly forged material. (Paper by Prof. J. H. Andrew, read before the Institute of British Foundrymen at Sheffield, England, July 4, 1935, abstracted through *Engineering*, vol. 140, no. 3639, Oct. 11, 1935, p. 405)

POWER-PLANT ENGINEERING

Pumping Hot Water Against High Pressures

THE use of high-pressure boilers superimposed on existing low-pressure plants in an effort to modernize the latter makes the question of pumping hot water against high pressures important. The percentage of the power output required for driving the boiler feed pump is appreciably increased at high pressures and the problems confronting the pump designer become more exacting, particularly as the pump must not only withstand a higher pressure with interstage or regenerative heating but the temperature of the water passing through the pump is also much higher. The author illustrates a boiler feedwater pump which has been used successfully for pressures up to 1600 lb and for temperatures around 300 F. A special feature is the means used for maintaining the axial balance.

As the impellers are of the single suction type, the unbalance of each impeller is (neglecting the slight thrust due to the reaction of the entering liquid and the reduction in pressure on the back of the impeller) due to the fact that that liquid between the impeller and the casing wall tends to revolve with the impeller, causing a thrust equal approximately to the pressure generated by that impeller multiplied by the annular area between the wearing-ring joint and the shaft. This net thrust is balanced by introducing a leakage joint past a balancing member of the last impeller, the leakage being bled off to the suction end of the pump. With a balancing area equal to the annular area of the suction side of the impellers and assuming suction pressure in the balancing chamber, the balancing member, which, as used

by some designers, has the form of a drum or cylinder with radial clearance, would be subject to a thrust equal to, but opposite in direction to, the unbalanced thrust acting on all of the impellers. However, due to uncertain factors, such as the pressures on impeller disks and the reaction of the entering flow before mentioned, a substantial thrust bearing would still be required.

In this pump the leak-off joint is radial and the clearance can be regulated by the axial position of the impeller. By making the area of the disk greater than the suction area enclosed by the impeller wearing rings, it is possible to keep the rotor in balance without reducing the pressure in the balancing chamber quite to the suction pressure, that is, leaving a margin for adjustment. (*The Marine News*, vol. 22, no. 5, October, 1935, pp. 22–23 and 26, 3 figs.)

The Superposition Turbine

BY superimposing a high-pressure turbine on an existing low-pressure plant the capacity of the latter can in many instances be nearly doubled and the turbine heat rate reduced to 10,000 or 11,000 Btu per kwhr with but little added capacity. This can be done, however, only if a fully reliable high-pressure turbine has been installed of a construction suitable for this service.

By way of illustration the author discusses a specific turbine of 25,000-kw rating with steam conditions of 1250 lb per sq in. gage, 900 F total temperature, and 185 lb per sq in. back pressure. The temperature of the exhaust steam is just over 500 F (as shown by Fig. 2 of the original article). Consequently, since steel is tempered at 450 to 550 F and glows at about 800 F, the design must take cognizance of the softening effect of high temperature.

The turbine recommended is of the Curtis reaction type. It operates at 3600 rpm, being direct-connected to a 60-cycle generator. Because of the comparatively small volume of steam handled and the high speed, small diameters can be used, which greatly simplifies spindle and cylinder construction.

The spindle is a single forging of high-grade alloy steel designed to operate with low stresses. The impulse wheel, for instance, is 24 in. in diameter and the reaction blade drum 20 in. For an ordinary 3600-rpm condensing turbine carbon steel would be used of such dimensions that the spindle could be over-speeded 100 per cent with safety, giving the superposition turbine three times the ordinary factors of safety. The cylinder is also made of alloy steel so that with conservative stresses it can be kept as light as possible so that it will follow the temperature changes of the steam more quickly and expand more nearly the same as the spindle. The steam chest is cast integral with the cylinder governor, thus eliminating the potential trouble of a flanged connection underneath a metal jacket.

It may seem odd that the thickest wall construction is not required in the steam chest because of its small diameter. Actually, the thickest walls are needed at the impulse chamber where the pressure reaches a maximum of 1000 lb and the walls are 3.75 in. thick, with a stress of 4000 lb per sq in. In actual operation, the need for such thickness of wall decreases toward the exhaust, but since it is impractical to isolate the high-pressure section for water test, the walls holding the following blade group are made of constant thickness and this whole section given an hydraulic test to 1500 lb per sq in. The exhaust cavity is, of course, tested to a pressure of only 300 lb per sq in.

The bleeder slot is located at the 450-lb point and steam from it can be bled for feedwater heating to 450 F if desired instead of to 373 F obtainable with steam that is taken from the turbine exhaust.

Of the many other features of this turbine attention is called to the following: The nozzle block is made by welding stainless-steel vanes, the unit there being annealed, machined, or overlapped to the cylinder. This construction permits the use of perfectly formed vanes for the nozzle passages with a sturdiness not always obtainable in other designs. The two-row impulse wheel has individual blades machined from stainless-steel bars; the T-roots are here an integral part of the blade. Seal strips are also used. They consist of thin strips of a special stainless steel set in a groove and held by a soft-steel calking strip, which is rolled into place. The material of the seal strip has been carefully selected so that, in case of a rubbing contact, the seal will wear away without injurious heating or wear of the part it touches. Before the spindle is installed in the cylinder, the wear strips are machined to give a slight clearance. During the first cycle of operation (starting, running, and stopping), the radial seals are worn back to arrive at a clearance normal for the turbine, which means, the least that can be maintained in service. While the preliminary running-in of commercial machines must always be done with due consideration of the value of the equipment involved, stringent tests have shown that with this design and material, the seal strips may be entirely worn away without injury to the more expensive parts with which they contact. Consequently, motives of safety no longer make it necessary to machine excessive clearances in order to preclude the possibility of a rub.

To obtain the full benefits of superimposing it is of the highest importance that this turbine be capable of being kept on the line practically all the time without appreciable deterioration. (Norris D. Gove, Turbine Engineer, Westinghouse Elec. & Mfg. Co., in *The Electric Journal*, vol. 32, no. 8, August, 1935, pp. 330–333, 7 figs.)

Washing Turbines

AT the Long Beach Steam Station of the Southern California Edison Co. a falling off in capacity was observed and traced to deposits occurring principally between the fifth and fourteenth stages of the 21-stage turbines.

The deposits consisted principally of sodium chloride and sodium carbonate, and took place mainly when the turbine was operated at or near full load. They were also influenced by blade roughness, boiler-water concentration, and the rate of steaming.

One of the means to take care of this matter has been washing the turbine blading. This is accomplished by operating the machine with saturated steam at 25 per cent of rated capacity. The only special equipment required is the desuperheating apparatus, which consists of a water-spray nozzle located 136 ft from the turbine throttle in each of the steam leads. These nozzles are supplied with condensate by a 1000-gpm boiler-feed pump, which is isolated from the rest of the feedwater system while washing to insure uniform delivery pressure. In the line between the pump and the nozzle a valve with straight-line flow characteristics is installed.

Further to facilitate desuperheating, the initial steam temperature is lowered by sectionalizing the boiler room and operating at low ratings the boilers used on the unit being washed. This reduces the normal steam temperature for 25,000-kw load from 685 to 640 F.

The most successful standard washing procedure is given in the original article, and it is stated that the success of the washing operation depends upon maintaining a constant pressure and temperature of steam to the turbine. (J. R. Zeigler in *Electrical World*, vol. 105, no. 13, June 22, 1935, pp. 36, 4 figs.)

RAILROAD ENGINEERING

High Speed on the Rail

A LITTLE over a month ago a speed of 112 mph was attained on a British railway with an ordinary locomotive, an ordinary passenger train weighing 230 tons, on an ordinary railroad, and under ordinary climatic conditions.

The writer deduces from this that there is nothing inherently impossible or even very difficult in the attainment of high speeds on British railways with locomotives and trains of the familiar kind. Mr. Gresley designed a special engine for this train, but save for the streamlined cover in which it is enclosed, and the raising of the boiler pressure from 220 to 250 lb, it is similar to any other "Pacific" built by him. It will not be forgotten that one of his old "Pacifics," built in 1923, made a speed of 100 mph last November with a train of 205 tons behind the tender. In fact, the new locomotive is an ordinary steam express engine of the most recent design. Stress is placed on this point because it seems essential that people should know that the familiar steam locomotive—the cheapest and simplest and lightest in upkeep of all kinds of locomotives—can do whatever may be achieved in the way of speed by employing exceptional designs.

The locomotive has been streamlined on the Bugatti or horizontal system. As far as the streamlining of the train is concerned, the gaps between the coaches have been closed but no attempt has been made to reduce the drag caused by the flat rearward end of the coach. In fact, it is claimed that it is impossible to do it. In the test run referred to, at the end of the outward trip the locomotive was transferred from one end of the train to the other.

Besides body streamlining Mr. Gresley has made an attempt to grapple with the undercarriage air resistance by fitting petticoats between the bogies of the coaches. The part that they may play in reducing—or increasing—air resistance will be watched with exceptional interest. The importance of such petticoats or curtains was demonstrated in a series of tests carried out in Canada on a model locomotive and tender and reported in *The Engineer* of April 14, 1933. But it is impossible to simulate the day by day conditions on an open railway by any wind-tunnel experiments so far discovered, and it may prove that, when all things are considered, the petticoats are more trouble than they are worth. Let it be said emphatically that the technical interest in this train is not the high average speed at which it is to be run—a speed which with a similar train could be attained and is attained by unstreamlined engines—but the reduction of power and consequently of coal and water consumption which it is hoped may be achieved by streamlining. Unfortunately, Mr. Gresley has no strictly comparable engine running on the same service, but he may, nevertheless, be able at the end of a year or so to satisfy himself that streamlining, by reducing head resistance, has actually resulted in more economical running. (*The Engineer*, vol. 160, no. 4160, Oct. 4, 1935, p. 351)

Data of Tests of a Streamlined Steam Locomotive

THE author begins by giving a brief history of tests of streamline equipment and incidentally touches on the subjects of effect of jacketing of the locomotive on the cooling of locomotive bearings, as well as the behavior of semijacketed standard locomotives. One of the most interesting parts of the investigation is that dealing with saving of power or drawbar pull as a result of streamline jacketing. This has been determined as the difference of the outputs of the jacketed and unjacketed locomotive at the so-called boiler limit, that is, for a predetermined maximum continuous steam production per hour—in this case 57 kg per hr per sq m of the heating surfaces. These data are given in Table 1.

TABLE 1 SAVINGS IN POWER CONSUMPTION AT THE DRAWBAR OF STREAMLINE JACKETED 03-LOCOMOTIVES

	Km per hr				
	60	80	100	120	140
Saving in drawbar pull, horsepower	50	60	115	175	215
Saving in percentage of output of unjacketed locomotives...	3.3	4.3	9.1	16.2	27.0
Aerodynamic saving in drawbar pull	5	33	85	140	172

The saving in power consumption appears in two lines of that table. The upper line figures of savings could have been considered as a pure saving, if it had not been for the fact that the jacketed locomotive has a higher temperature of exhaust which leads to an improvement of about 2.5 per cent in the working process in the steam cylinders, which, because of the jacketing, are better protected against heat losses. The appropriate figures of savings determined from indicator diagrams are subtracted then and this gives the lowermost line of the figure which represents the true aerodynamic savings due to the use of jacketing.

Only the use of high velocities justifies the increased first and maintenance costs of the jacketing of locomotives. (Prof. H. Nordmann, *Zeitschrift des Vereines deutscher Ingenieure*, vol. 79, no. 41, Oct. 12, 1935, pp. 1226–1229, *eA*)

Russian 4-14-4 Locomotive

THIS is a nonarticulated heavy freight locomotive designed to meet peculiar local conditions. It made several trial runs before it was placed in service. When handling a train of 1400 tons at a speed of 25 mph on a heavy grade the locomotive developed 3000 hp. Certain features of this unusual machine are particularly interesting.

Especially noticeable is the large size of the boiler and the firebox. The boiler is of the straight-top radial-stayed type, the center line being 11 ft $11^3/_4$ in. above the top of the rail. The total length of the boiler is 58 ft $7^5/_8$ in, and its weight is approximately 132,000 lb.

The firebox is 15 ft 9 in. long and 8 ft $2^7/_{16}$ in. wide, which gives a grate area of 129.2 sq ft. Such a large grate area would not be required were the coal not of such a low grade. The grates are of the shaking type, a mechanical grate shaker operated by either steam or compressed air being provided. The coal is fed by a mechanical stoker. The ash pan is of the hopper type.

A combustion chamber, 8 ft $2^7/_{16}$ in. long, is provided which increases the firebox volume to 865.2 cu ft. A brick arch is applied, the arch being carried on four arch tubes that are $3^1/_2$ in. in diameter.

The evaporative heating surface of the boiler has an area of 4822.7 sq ft, of which 595.4 sq ft is in the firebox and 4227.3 sq ft in the tubes and flues. Adding 1872.9 sq ft of superheating surface brings the combined evaporating and superheating surface to 6695.6 sq ft. The evaporative capacity of the boiler is estimated to be 73,716 lb per hr, which corresponds to a potential or boiler horsepower of 3880.

Assuming a combustion rate of 82 lb per sq ft of grate per hr, the total amount of coal burned would be 10,594 lb per hr. If one horsepower could be developed for each 2.65 lb of coal, the total horsepower would be 4000.

A particularly interesting feature of the boiler construction is the extensive manner in which welding was employed, mainly to keep down the weight, but partly to permit of the use of sheets of readily available sizes. All welded seams are of V-shape and are located between lines of stay bolts. The firebox sheets, both inside and outside, are welded, being formed of several sheets joined together by welding. The crown sheet and back boiler head are also made of two or more sheets with welded joints.

The main rods are 13 ft $1^9/_{16}$ in. long. Despite their great length the distance between the center of the cylinders and the fourth axle is so great that the piston rods are 13 ft $1^9/_{16}$ in. long. To keep down the reciprocating weights and to make unnecessary the employment of piston rods of abnormal diameter, resort was had to a secondary supporting crosshead located midway between the cylinder and the main crosshead. The main crosshead is of the multiple-ledge type developed on the Pennsylvania Railroad.

The provisions for safely passing around sharp curves at considerable speed and the avoidance of heavy side thrusts and side wear on the rail due to the long wheel base are described in the original article. Spring rigging follows the usual American practice. Three-point suspension is provided by dividing this spring rigging into three groups.

Notwithstanding the heavy weight of the moving parts (main rod 1610 lb, piston, piston rod, and crosshead 2485 lb) and the high running speed of 43.5 mph anticipated for the locomotive, it was possible to counterbalance all the rotating masses and the necessary part of the reciprocating parts. (D. Babenko, *Railway Age*, vol. 99, no. 16, Oct. 19, 1935, pp. 493–495, 1 fig.)

SPECIAL MACHINERY

Rapid Method for Determining and Correcting Unbalance

THE author reviews various types of balancing machines. In the new method the pivoted carriage is replaced by a simpler mounting and an electrical circuit and network.

The functioning of this arrangement depends on the relation, which exists for almost any mounting, between the balance correction in one plane and the vibrations of any two given points of the rotor axis. The vibrations at two points on the axis are converted into two corresponding voltages by magnetic pick-ups similar to those employed for turbine-blade and rotor-vibration studies at the South Philadelphia Works of the Westinghouse Electric and Manufacturing Co. and described by R. P. Kroon in the June, 1935, *Instruments*. These voltages are placed on the network in which the same relation obtains between them and a third voltage (produced by them in the network) as obtains between the vibrations at the two given points of the rotor axis and the unbalance correction in one balancing plane.

Thus this third voltage corresponds in both phase and amount to the unbalance effect at one correction plane; similarly the third voltage of a second network corresponds to the unbalance effect at the other correction plane, the input voltages to this second network being the same as those of the first, namely the pick-up voltages.

The unbalance in one correction plane having been converted into a voltage proportional to the unbalance and in fixed phase relation with it, the problem becomes simply that of measuring the value of this voltage and its phase with respect to the rotation of the rotor.

The typical apparatus for production balancing and procedure in balancing are set forth in the original article. Of interest is a short passage dealing with automatic balancing. (F. C. Rushing in *Instruments*, vol. 8, no. 9, September, 1935, pp. 228–231)

Vacuum Equipment for Drying, Gas Extraction, and Cooling

THE author begins by stating the fundamentals of vacuum drying and says that the general aim in designing the machinery is to shorten the "tail" part of the process as much as possible, while at the same time maintaining a low temperature. A simple solution of this problem is the employment of a high vacuum for vapor condensation. The author shows a tube-type evaporator equipped with an external-circulation heating element usually heated with saturated steam, where the lift of the vapor bubbles is utilized for obtaining high throughput. When equipped with separators built into the circulation, this type of drier is well suited to the evaporation of salt-excreting solutions. Where a higher degree of concentration must be obtained, it is necessary to resort to agitator-type evaporators, and where small outputs are concerned the two appliances must be combined into a single piece of equipment. With the aid of the circulation heater the major volume of moisture is first expelled in the preliminary evaporation stage. The circulation heater is then cut off and run out of the way to one side, and by the action of the built-in agitator and by heating the double bottom, final evaporation is carried out to the point of viscosity and pasty consistency of the material.

For large outputs agitator evaporators are troublesome to handle and have the drawback that, as a rule, it is impossible to take advantage of higher temperature drops because of the danger of resultant overheating. In such cases preference is given to continuously working film evaporators. There is also a group of appliances periodically charged, such as drying cabinets, vertical-type agitators, and scoop driers. In these continuously charged driers the drying process cannot be separated into individual stages. Film driers, scoop-type driers, and vertical-flow-type driers belong to this latter class. Examples of all such kinds of machines are illustrated in the original article.

From this the author proceeds to the discussion of vacuum appliances which work without continuous heat input, such as deaerators and gas extractors, used in feedwater preparation and for conserving the vitamins of milk. They are also used for deaeration of solids to the end of obtaining the greatest possible density of structure and strength (manufacture of stoneware, bricks, and porous fabrics).

A decision as to whether a process is best carried out in a vacuum or at normal air pressure can be arrived at only by considering the circumstances involved in each case. In almost all instances operating costs will be the decisive factor, and these costs are largely influenced by steam consumption. Where, therefore, only small quantities of moisture must be evaporated and no low temperatures are required, or where a surplus of waste heat is available, it will be preferable to carry out the process at normal atmospheric pressure, because the higher first cost of the vacuum plant is not offset by savings in operation. In all other cases the use of the vacuum process will be preferable, because steam consumption amounts to only a fraction of that required with pressure air drying. The power needed for the generation of a vacuum is overestimated as a rule, inasmuch as it is generally below the power consumption of the blowers used for pressure-air driers. (E. L. Holland-Merten in *Engineering Progress*, vol. 16, no. 9, September, 1935, pp. 235–239, 14 figs.)

SPECIAL PROCESSES

New Processes for the Generation of Oxygen

THE process here described produces a technical oxygen, which means a rich oxygen-nitrogen mixture. It is characterized by a low power consumption and the elimination of preliminary cleaning of the air.

Theoretically, in order to break up the air, it is merely necessary to expend work of compression which would bring the oxygen and nitrogen from their partial pressures of 0.2 and 0.8 atm abs, respectively, to the pressure of 1 atm abs. The theoretical minimum consumption of energy per one cubic meter of pure oxygen is 0.1 hp-hr. In commercial processes such as the so-called double rectification, one must employ a compression of the entire air to 3.6 atm abs. At this pressure the nitrogen has exactly the same boiling point as oxygen at atmospheric pressure. Because of this, a heat exchanger is built into the so-called two-side rectification column, and the pipes of this exchanger act on one side as cooling surfaces for the condensation of nitrogen at 3.6 atm abs and at the other side as heating surfaces for the evaporation of oxygen at atmospheric pressure. If conditions are favorable a power consumption of about 0.22 hp-hr per cu m of pure oxygen is obtained. In actual practice the expenditure of energy is more than twice as much.

Lachmann showed, however, that it is not at all necessary to bring to the same high pressure all the air that is to be handled and then to evaporate it. According to him it is enough to compress to a high pressure only a part of the air, and the liquefied portion thereof constitutes then a "wash fluid." The other part, the so-called "gas bubble air" remains in the gaseous state and needs to be subjected to only a very small pressure, 1.1 to 1.2 atm abs.

The rectifying apparatus used for the separation of the gases in accordance with this process is then provided with cascading inserts over which the "wash liquid" runs downward, while the air bubbles previously cooled to the condensation temperature run upward. The liquid running downward "washes" the air bubbles out of the oxygen while the liquid itself gives up nitrogen. This nitrogen escapes to the upper part of the rectifying apparatus, while liquid oxygen collects at the bottom and from it gaseous oxygen is obtained by evaporation.

This process brings a reduction of the power consumption to a theoretical value of about 0.13 hp-hr per cu m of pure oxygen. If, however, the machine produces the so-called technical oxygen, that means a gas with a content of about 45 per cent oxygen, then the power consumption required to cover the cold losses is about 0.13 hp-hr.

Hitherto, the process has not found practical application, because to cool the air bubbles at their low pressures requires an enormous cooling surface and the process is accompanied by considerable pressure losses. Furthermore, it is necessary to provide against dirt deposits in the counterflow coolers, which means that the air has first to be cleaned.

Fränkel has gotten around this difficulty by installing, instead of counterflow coolers, regenerators, that means, heat exchangers, with metallic inserted structures, which alternately are in contact either with the nitrogen or oxygen obtained, or the air flowing in. This requires a constant switch of the gases from one heat exchanger to the other. In this way the pressure losses are as low as in counterflow coolers, but, in addition, deposits of ice or solid carbon dioxide from the air do not do any harm, because they are sublimated (this means eliminated in a dry state) by the gases flowing over them. The process is particularly suitable for the production of technical oxygen with a content of the latter of about 45 per cent, because with this figure a favorable state of equilibrium is obtained in the apparatus. Moreover, the production of an oxygen-rich mixture requires less consumption of power than the production of pure oxygen. The details of the process and machinery used are given in the original article, but cannot be abstracted here because of lack of space. (Dr. F. Kaiser, *Zeitschrift des Bayerischer Revisions Vereins*, vol. 36, nos. 4 and 5, Feb. 28 and Mar. 15, 1935, pp. 27–30 and 37–41, 4 figs., *dA*. Compare article by Ernst Karwat in *Stahl und Eisen*, vol. 55, no. 32, Aug. 8, 1935, pp. 860–863, 2 figs., *d*)

STEAM ENGINEERING

Heat Transmission in Boilers

THE heat transmitted to water surrounding a long fire tube having hot gases flowing through it varies, according to the author's experiments, as $V^{0.85}$ (V = velocity).

The heat transmitted to water by a nest of water tubes arranged in staggered formation, with the gases passing over them at right angles to their axes, varies, according to published experiments, as $V^{0.68}$.

The heat transmitted to water by a nest of water tubes arranged in parallel rows with gases passing over them at right angles to their axes varies, according to published experiments, as $V^{0.654}$.

It follows that the water-tube boiler with tubes arranged in staggered formation obtains but a slight advantage over one with tubes arranged in parallel formation, but that the fire-tube boiler obtains a marked advantage over both when gas velocities are increased. For example, in the event the velocity of gases is quadrupled in each case the heat transmission by convection is accelerated as follows: In the fire-tube boiler, 3.25 times; in the water-tube boiler with staggered fire tubes 2.57 times; in the water-tube boiler with parallel fire tubes 2.48 times.

The fire-tube boiler has another great advantage over the water-tube boiler in that the combustion products passing into the fire tubes have only to be accelerated once, whereas in the case of the water tubes the velocity of the gases is accelerated and decelerated at every row of tubes.

The author is of the opinion that these are the two reasons why the fire-tube waste-heat boiler, which does practically all its work by convection, has nearly ousted the water-tube boiler from the waste-heat-recovery field when pressures do not exceed 250 lb per sq in.

The author points out that when hot gases are flowing through a fire-tube surrounded by water the temperature of the gases, their density and their velocity vary, while the specific heat also varies as the temperature drops. It was suggested some time ago, and the idea has been recently revived, that it would be advantageous to keep the velocity of combustion products constant in both water-tube and fire-tube boilers by reducing the cross-sectional flue area as the temperature of the gases fell. The author does not believe that this idea is correct, and tries to prove it by a calculation which cannot be abstracted here.

When hot gases are flowing at a mean velocity of, say, 70 ft per sec through a fire tube surrounded by water there are two forms of turbulence impressed upon these gases. The first, and by far the most important, kind of turbulence is that due to the entering velocity of the gases, which may be accelerated suddenly from 20 to perhaps 100 ft per sec at the inlet end of the tube, thus causing a tremendous disturbance of gas molecules. The creation of this inlet turbulence may absorb nearly 50 per cent of the total draft required to draw the gases through the tubes, but it enables the molecules of gas to transmit their heat content to

one another and to the tube walls much more quickly.

What happens is that the molecule takes the shortest path it can find from the inlet to the outlet of the tube and passes its heat content to another molecule nearer to the tube wall, which in turn does the same. Thus the heat reaches the wall without the molecule that possesses it coming in contact with the wall. This is the reason why straight tubes have to be so enormously long if real efficiency is to be obtained with high mean velocities of gas flow. For example, a transmission efficiency of 90 per cent with a mean velocity of 70 ft per sec requires a straight tube about 160 diameters in length.

Data of experiments on the percentage of draft drop used in creating inlet turbulence are given in the original article. It is not stated what the second kind of turbulence is.

The author claims to have developed a new tube producing an acceleration of heat transmission of 150 per cent and data of tests of this tube are reported in the original article. There is a separate gas jet opposite each tube and combustion takes place in the tube, so that the bottom tube plate is not subject to high temperature. This enables them to be made for pressures as high as 750 lb per sq in. (P. St. George Kirke, paper before the West of Scotland Iron and Steel Institute, abstracted through *The Steam Engineer*, vol. 5, no. 49, October, 1935, pp. 23, 24, and 27)

TESTING AND MEASUREMENTS

The Hele-Shaw Apparatus for the Investigation of the Flow of Metals

THE apparatus was primarily developed in 1897 but modified and improved since. It consists of two glass plates separated by a model made of drawing paper of the contour to be examined. Colorless glycerine passes into a cavity and then flows down within the die. Another supply of glycerine colored with a red aniline die passes into another cavity which is closed by a brass plate at the lower end of which a series of small equidistant holes is drilled. Alternating streams of red and colorless glycerine thus pass down between the plates and reveal the streamline characteristics of the particular shape of the die under investigation. An attempt has been made to apply this apparatus to the examination of some simple forms of drop stamping, to the drawing of tubes, and to the nature of the flow during the drawing of wire.

For many reasons exact concordance between the model flow and the actual piece must not be expected, but the apparatus is capable of yielding clear qualitative information regarding the manner in which metal may be expected to flow when stamped between dies. The authors have extended this method of testing so as to show the effect of inclusions. (Paper by A. M. Herbert and Prof. F. C. Thompson before the Iron and Steel Institute, Manchester, England, Sept. 18, 1935, abstracted from abridgement in *Engineering*, vol. 140, no. 3637, Sept. 27, 1935, pp. 347–348, 10 figs.)

Comparative Measurements of Turbulence by Three Methods

THERE are three methods of measuring turbulence in use at the National Physical Laboratory, namely (*a*) the hot-wire method, (*b*) the ultramicroscope method, and (*c*) the spark method, all of which are fully described elsewhere. Of these the first is the oldest and has been most extensively used; the other two are comparatively new. The essential distinction between the methods is that the hot wire records fluctuations at a point fixed in space, while the other two methods record the motions of elements of fluid moving with the stream. The latter are, therefore, less influenced by the frequency of the velocity fluctuation at the point of observation. In view of these differences it was important that comparative measurements be made by the three methods under identical flow conditions in order to establish the accuracy obtainable in each case. Accordingly, experiments were made in an air stream in which different degrees of turbulence were obtained by passing the stream through a contraction.

Air from a centrifugal fan was led through a long pipe to a large chamber communicating with the entrance to the contraction. The cross section of this chamber was made large to obtain a low velocity of approach, and contained a honeycomb which eliminated any large swirl. The flow was further stabilized by a bellmouth leading to the inlet of the contraction. Large disturbances in the flow were generated by a grid of square mesh placed across the stream in the parallel portion of the inlet. Immediately behind the grid the vortex system so formed was regular, and by the time the stream reached the first position for measurement the vortices had become fairly well diffused.

Observations of the longitudinal component of turbulence by the three methods and of the lateral component by the spark method were made at points on the axis at positions in the inlet and outlet of the contraction.

The ratio of root-mean-square values to maximum values obtained by the hot-wire and spark methods are in good agreement, as also are the ratios of the turbulence in the inlet and outlet by all three methods. Any of the three methods, therefore, gives reliable indications of the comparative turbulence in different flows. The type of experiment chosen in the present case was of a particularly drastic nature, for in the inlet the flow was disturbed while in the outlet the disturbances were small. In consequence the accuracy is not high but it is probable that the data are accurate to within ± 10 per cent, since they are in most cases the means of several measurements. The accuracy of the root-mean-square values is probably higher than this. The absolute values obtained by the three methods are in less satisfactory agreement, the ultramicroscope and spark methods giving higher values than the hot wire. (Staff of the Aerodynamics Department, National Physical Laboratory, Reports and Memoranda of the British Air Ministry, No. 1651, Oct. 25, 1934, original document, 17 pages and 8 diagrams)

TEXTILE ENGINEERING

Spindle Speeds and Yarn Tension in Ring Spinning

AS A rule a ring-spinning frame is required to deal with a wide range of raw materials and counts, for each of which there is a more or less defined optimum spindle speed. Tension is caused by the centrifugal force of the rotating traveler and the yarn balloon, which means that it depends on the spindle speed and weight of the yarn, and makes a wide and unbroken range of speed regulation of the driving motor one of the essentials of the ideal ring-frame drive. Where the frames are driven from line shafting or individually by constant-speed motors, speed regulation is unusual, and the author proceeds to specify the desirable characteristics of a motor for ring-frame driving. Before such a motor could be developed, however, the Siemens-Schuckert concern undertook the construction of an electrical yarn-tension recorder which showed the course of variation of the tension during the process of spinning. These fluctuations are the cause of breakages in spinning and uneven winding.

The conclusion to which tests made

with this instrument have brought the author is that the principle of spinning at variable spindle speed and constant yarn tension touches the production of yarn in all its aspects, i.e., the strength and elasticity of the yarn, the firmness of the cops, the quantity produced, and the attendance required.

This led to the development of a special ring-spinning motor which is a three-phase variable-speed spinning motor with shunt characteristics, but so connected that the disadvantages of rotor regulation are avoided and an unbroken range of speed regulation is obtained without attendant losses by inserting in the stationary stator winding a variable counter electromotive force instead of resistances. For the purpose of tapping varying values of the counter electromotive force, a commutator is equipped with two sets of brush gear, arranged to move in opposite directions so that the rotor assumes a speed which is below or above synchronism. The drop in speed due to increasing load is only slight. The motor is, moreover, practically independent of fluctuations in the supply voltage.

The speed range of the spinning motor for cotton and bast fibers is usually 1 to 2, and for worsted yarns 1 to 3. Since the motor is also switched on and off by the lever used for speed regulation, its manipulation is an extremely easy matter.

The object of the spinning regulator is to control automatically the motor speed in such a way as to produce a speed diagram on the lines of Fig. 10 in the original article. There are three points of adjustment in the speed regulator as set forth in detail in the original article. It is claimed that in variable-speed spinning there are fewer breakages and hence fewer piecings or knots, the yarn is better and stronger, and production is higher. (*The Textile Manufacturer*, vol. 61, no. 730, October, 1935, pp. 417–418 and 431, illustrated)

Variable-Speed Drive of Ring-Spinning Frames

THE problem of equalizing the tension of the thread through variation of the spinning speed has been attacked by Brown, Boveri & Co. through the introduction of their special motor, which is a three-phase shunt commutator motor with Schrage connections. In addition to its other characteristics this motor is of a restricted length so that it can be installed in very limited quarters.

Contrary to the mode of operation of the selfacting mule spinning and winding are continuous and simultaneous operations on the ring-spinning machine. This constitutes an economic superiority for the latter, but has a certain disadvantage as regards the spinning process itself. The conditions requisite for spinning and winding are not entirely fulfilled. The very wide fluctuations in the tension of the thread, when spinning at constant speed, affect its quality and set a limit to the working speed, which prevents the full productive capacity of the machine from being even approached.

Because of the low operating speed, motors to drive worsted-yarn spinning frames are designed with high-grade oil-immersed reduction gears built into the bearing shield. The design of motor with a reduction gear is also suitable for the drive of bast-fiber flyer-spinner and doubling frames. A spinning regulator is not usually used here, but drives which can be regulated, as in the case of ring-doubling frames, are of great importance; the reason is that adaptation to the most favorable speed for the different yarn numbers and doubling effects and readjustment by hand during spinning or doubling has proved, in practice, to have technical and economic advantages.

The advantages of the variable-speed drive of ring-spinning frames and doubling frames by three-phase shunt commutator motors can be summarized as follows: The revolutions per minute and the spinning speed remain stable even under fluctuations in the load or in the supply voltage. For average and fine yarn numbers the spinning speed can be automatically governed by the formation of the cop in such a way that the thread tension is compensated for and the winding of the bobbin is improved. Although the spinning speed is greater, there are fewer thread breakages. The machine produces more and better yarn. Quite fine yarn up to the very finest, of even and soft quality, can be spun on the cheaper and simple ring-spinning frame instead of on expensive selfacting mules which take up so much room. (*Brown Boveri Review*, vol. 22, no. 11, November, 1935, pp. 207–210, 4 figs. Compare article, "Individual Electric Drives in Bast-Fiber Spinning Mills," on pp. 222–224 of the the same issue of *Brown Boveri Review*, 3 figs.)

THERMODYNAMICS

Heat Transfer in the Course of Evaporation of Liquids in Contact With Vertical and Horizontal Surfaces

THIS investigation is part of a series devoted to the subject of the processes of evaporation and deals primarily with heat transfer during the evaporation. They were done with water and carbon tetrachloride, and the process of evaporation itself was carried with wide variations in the load on the heating surfaces. It is claimed that a new application of equations of similarity has been found dealing with the heat transfer in evaporation. Among other things was investigated the influence of the geometric relationships of the vessel in which the evaporation was carried on on the heat transfer and observations were made on steam bubbles. One chapter is devoted to a dimensional representation of the heat transfer in evaporation. This includes the heat-transfer equations for the range of contact with steam bubbles.

With carbon tetrachloride and a horizontal heating surface there was found a maximum load of heat transfer of 240,000 kcal per sq m per hr, corresponding to an hourly evaporation of 5200 kg per sq m of heating surface. The equations of similarity set up to determine the heat transfer correspond, up to loads on the heating surface of 2000 to 4000 kcal per sq m per hr in the case of vertical, and 5000 to 10,000 kcal per sq m per hr in the case of horizontal heating surfaces, to well-known equations for free convection when there is no change of the state of aggregation. Probably because of the earlier appearance of turbulence, horizontal heating surfaces show a better heat transfer than vertical surfaces.

Above the limits of load just specified there appears a powerful contact effect on the surface of steam bubbles which form and rise. This affects materially the law of heat transfer.

Auxiliary measurements were made on the influence of the size of the vessel, the level of liquid, the magnitude and frequency of steam bubbles, and the number of places where they form. With this information in hand it becomes possible to set up simple equations of similarity to cover this region. It was found on the basis of tests that lasted for many days that with pure liquids the lowest value of the coefficient of heat transfer is directly proportional to the 0.8 power of the load on the heating surface and inversely proportional to the square root of the surface tension.

A comparison with the results of similar tests made by Cryder and Gilliland (*Refrigerating Engineering*, vol. 25, p. 78, 1933) who operated with freshly polished heating surfaces leads to the conclusion that their equations for the heat transfer of various evaporative liquids should not be used for ordinary operating conditions. (M. Jakob and W. Linke, *Physikalische Zeitschrift*, vol. 36, no. 8, Apr. 15, 1935, pp. 267–280)

LETTERS AND COMMENT

Brief Articles of Current Interest, Discussion of Papers, A.S.M.E. Activities

Origin of "Gas"

To the Editor:

In the article on "Atmospheric Air" in your issue of November, 1935, the following statement is made: "The word 'gas' was first used by van Helmont in the 16th century and was undoubtedly derived from *Geist*, the common German word for spirit, thus indicating van Helmont's idea that a gas was a substance intermediate between matter and spirit."

This statement is in error. Van Helmont says definitely that he devised the name *gas* from the *Chaos* of the ancients ("halitum illum *Gas* vocavi, non longe a Chao veterum secretum"). This appears in his "Ortus Medicinae," which was published in 1648 and consequently not in the 16th century.

Lionel S. Marks.[1]

[1] Professor of Mechanical Engineering, Harvard University, Cambridge, Mass. Mem. A.S.M.E.

Standard Specifications for Lubricants

To the Editor:

Mr. Lehman in his letter in the November issue, page 732, on "Classification of Lubricants" commenting favorably upon the conclusions found by Virgil M. Palmer and Horace C. Smith, states the lubricating-oil situation conservatively and gently.

It is probably unnecessary to make a stronger or more emphatic presentation of the matter as most mechanical engineers are faced with lubrication problems and are supplied with a heterogeneous mass of sales information and misinformation about lubricating oils.

As direct, practical tests (cut and try), on installed equipment, if adverse, may have disastrous and costly results, the careful engineer is constrained to make more or less expensive and delaying laboratory tests on samples before applying the practical test.

Today, with heavy-duty and high-speed equipment, the problem is greatly intensified.

I would urge that the question be not shelved at this time, but that forward steps be taken immediately to improve the situation.

One suggestion for the proper resolution of this indeterminate perplexity would be for The American Society of Mechanical Engineers to sponsor an A.S.A. standard specification for lubricating oils, to organize a committee to formulate such a standard, and to invite other engineering organizations and manufacturing associations to appoint representatives to serve on the committee or to act as co-sponsors.

Harry E. Harris.[2]

[2] Consulting Engineer, Bridgeport, Conn. Life Member, A.S.M.E.

Venturi and Weir Measurements[3]

To the Editor:

What the writer has to say with respect to the weir is built around the following bit of differential calculus from which we may infer that the error of the weir is three times that of the venturi meter for the same error in head measurement.

For the venturi meter

$$q = K\sqrt{h}$$

Differentiating

$$dq = {}^1/_2(Kdh/\sqrt{h})$$
$$= {}^1/_2(K\sqrt{h}\ dh/h)$$

or

$$dq/q = {}^1/_2(dh/h)$$

Hence, an error of one per cent in measuring the head produced an error of one half of one per cent in q.

For the rectangular weir

$$q = Kh^{3/2}$$
$$dq = {}^3/_2(K\sqrt{h}\ dh)$$
$$= {}^3/_2(Kh^{3/2}dh/h)$$

or

$$dq/q = {}^3/_2(dh/h)$$

This is three times the error of the venturi meter for the same error in h.

For the V-notch weir

$$q = Kh^{5/2}$$
$$dq = {}^5/_2(Kh^{3/2}dh)$$
$$= {}^5/_2(Kh^{5/2}dh/h)$$

or

$$dq/q = {}^5/_2(dh/h)$$

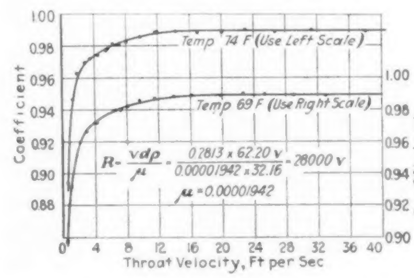


FIG. 1 COEFFICIENTS OF VENTURI METER

which indicates five times the error of the venturi meter.

That this is actually so is evident from the examination of Fig. 1 for an $8 \times 3^3/_8$ in. venturi meter wherein the points lie very close to the line, the probable error being extremely small.

Fig. 2 shows a set of suppressed and contracted-weir experiments. It will be observed that the points are off the mean line to a maximum of one per cent.

Fig. 3 shows similar information for a V-notch weir in which we should expect that the error will be five times that of the venturi meter. It is evident in the case of the 90-deg V-notch weir that the points are very much scattered.

The same weighing apparatus, timing devices, and head-measuring devices were used in all these experiments.

The writer's laboratory is of heavy reinforced-concrete construction with cast-iron weir plates and bronze crest. Checks on the elevation of the crest of the weir prior to the summer of 1935 have always shown it at the same elevation. During the summer and fall of 1934 it settled some seven-thousandths of a foot and this was discovered when

[3] A discussion of the paper "Venturi and Weir Measurements," by Charles M. Allen and Leslie J. Hooper, Mechanical Engineering, June, 1935, pp. 369–374.

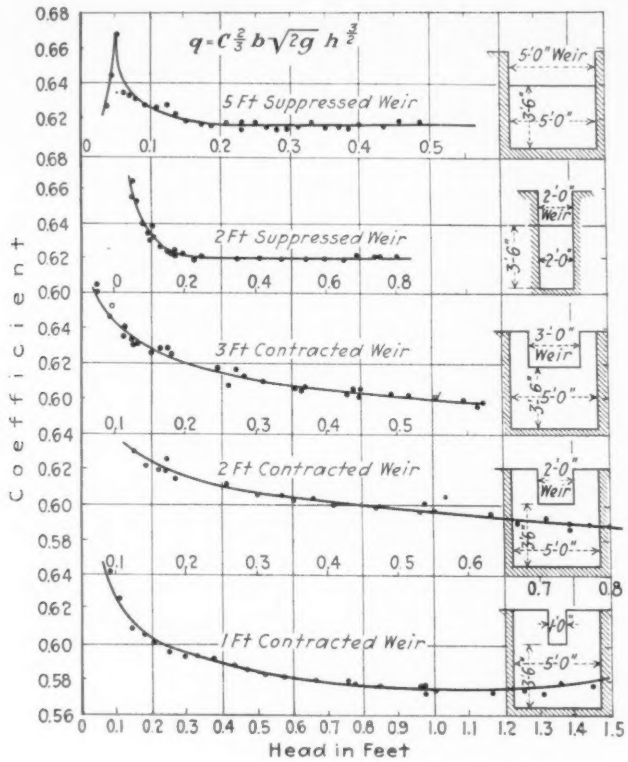


FIG. 2 COEFFICIENTS OF RECTANGULAR WEIRS

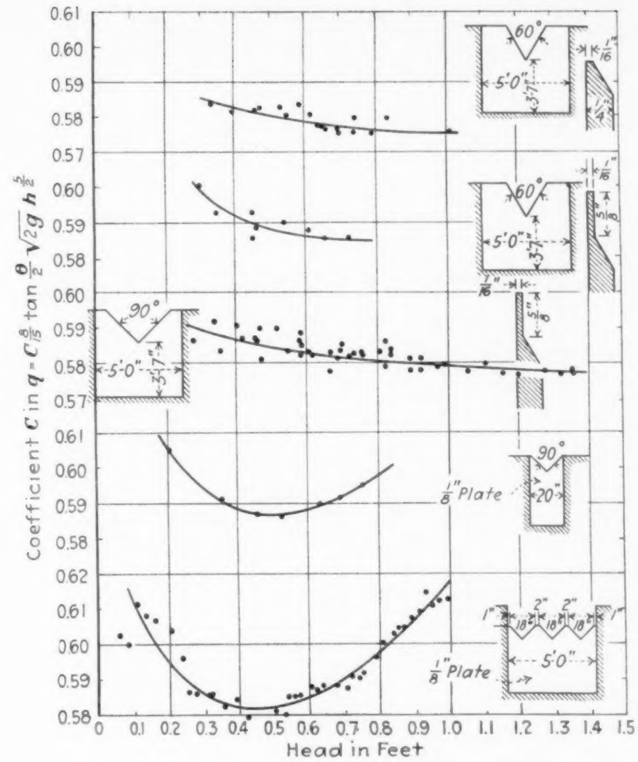


FIG. 3 COEFFICIENTS OF V-NOTCH WEIRS

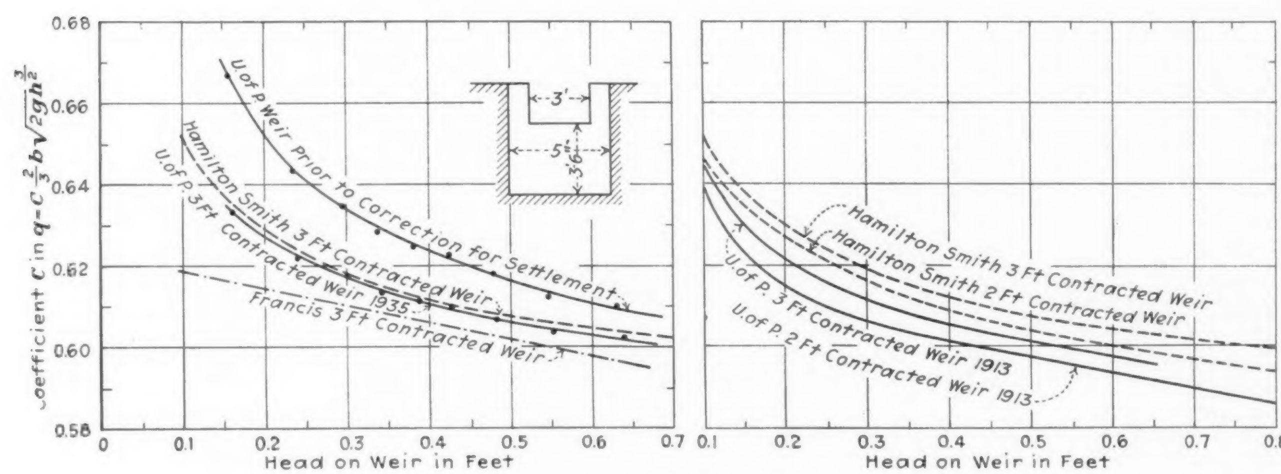


FIG. 4 COMPARISION OF COEFFICIENTS OF 2-FT AND 3-FT CONTRACTED WEIRS

a test conducted on the weir gave the upper curve shown in Fig. 4.

The crest elevation was corrected and gave the curve labeled "U. of P. 3-ft contracted weir, 1935." It is substantially in agreement with Hamilton Smith's 3-ft contracted weir shown immediately above it.

On the lower part of Fig. 4 is shown Hamilton Smith's 3- and 2-ft contracted weir and the U. of P. 3- and 2-ft contracted weir in 1913. It would appear in the intervening 22 years, due to increased roughness of the weir plate and a possible rounding of the crest, that the coefficient has risen some one per cent or there about.

All Professor Allen's corrections of Hamilton Smith's formulas are above unity. All the U. of P. corrections would be below unity. This merely emphasizes the point that the weir is a rather unsatisfactory device for measuring flow of water and is fast becoming a bit of laboratory apparatus which should be calibrated in place and then used immediately.

The writer presents herewith some data on the performance of a 12 × 6 in. Simplex venturi meter. This meter is of the ordinary construction cast-iron cone and brass throat piece. It was calibrated in 1919 with 21 feet of 12-in. wrought-iron pipe ahead of it as shown in Fig. 5. The mean coefficient above 12 fps was 0.9767.

It was installed in the permanent piping of the hydraulic laboratory as shown in the lower part of Fig. 5 with two 8-in. 45-deg elbows, an 8 in. to 12 in. enlarger and 12 feet of cast-iron pipe before it. The arrangement was such as to possibly

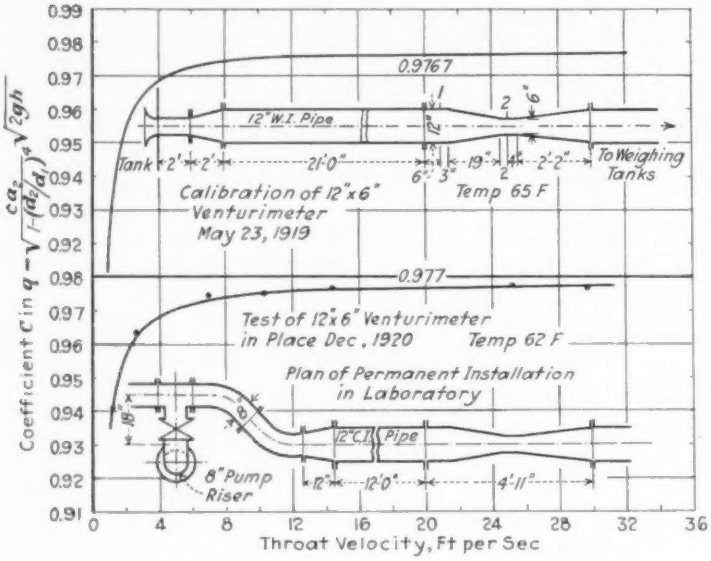


FIG. 5 CALIBRATION CURVES SIMPLEX VENTURI METER

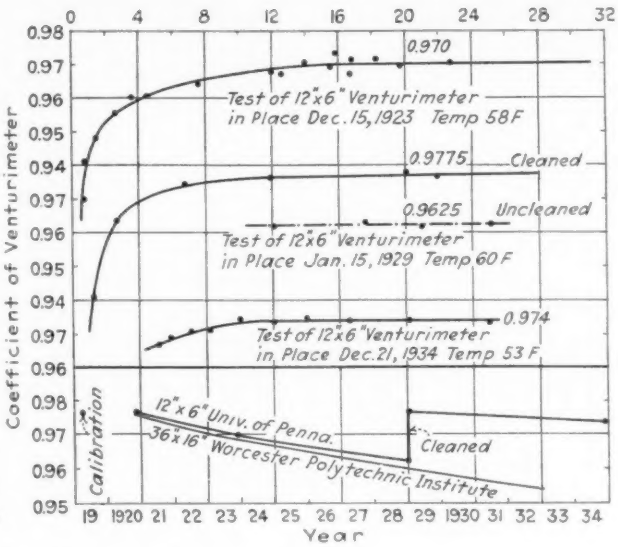


FIG. 6 COEFFICIENTS OF SIMPLEX VENTURI METER AND COMPARISON WITH ALLEN AND HOOPER COEFFICIENTS

produce an undesirable vortex in it. It would appear that this was not serious as the value of the coefficient was 0.977 in 1920 immediately after installation.

In 1923 this meter was used in connection with some tests of a Simplex integrating and recording meter. The test points are shown and the coefficient had fallen to 0.970 in three years.

In 1929 another series of tests of the Simplex meter was started and the coefficient found to be 0.9625. The venturi meter was then taken out of the line, cleaned, and retested, bringing the coefficient back to 0.9775. This meter was tested in December, 1934, for this discussion and gave a value of 0.974. These points were plotted at the bottom of Fig. 6 and give a remarkable agreement with Professor Allen's 36 in. × 16 in., Worcester Polytechnic Institute meter.

Point *A* on Professor Allen's Fig. 3 would seem to indicate that the venturi meter is profoundly affected by relatively small changes in the condition of the upstream conduit. The writer does not believe that Professor Allen's explanation explains and published some tests on a 2 in. × 1 in. venturi meter in the Transactions of A.S.C.E., December, 1927, page 577, which indicate rather minor effects of approach conditions for low-ratio meters.

Therefore the writer, with this experience back of him, does not feel that a bit of moss on the inside of a 40-in. penstock 8 diameters upstream from a 36 in. × 16 in. venturi meter could have had the effect indicated by point *A*.

Usually abnormal coefficients in venturi meters are brought about not by the approach conditions, but by conditions between the main and throat piezometers.

When venturi meters are apparently clean and seem to give abnormal coefficients, the trouble can usually be located in the throat-piezometer openings. Professor Allen has given us an excellent discussion of this in his paper.[4]

W. S. PARDOE.[5]

[4] "Piezometer Investigation," by C. M. Allen and L. J. Hooper, Trans. A.S.M.E., vol. 54, 1932, paper HYD-54-1.

[5] Professor of Hydraulic Engineering, University of Pennsylvania, Philadelphia, Pa.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information on the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following are records of the interpretations of this Committee formulated at the meeting of October 24, 1935, and approved by the Council.

CASE No. 810

(In the hands of the Committee)

CASE No. 811

(Interpretation of Pars. P-102i and U-68i)

Inquiry: In connection with the X-ray examination of welds, the Code specifies that the ratio of the distance between the focal spot and the outer side of the plate to the distance between the outer side of the plate and the film shall be not less than 7. Would it be acceptable to reduce this ratio to 5 when a grid of the Buckey type is employed to reduce scattering radiation?

Reply: Since recent reliable evidence indicates that in the case of X-ray films made with a grid of the Buckey type to reduce scattering radiation, a reduction of this ratio mentioned from 7 to 5 is, on the whole, more satisfactory, it is

the opinion of the Committee that in such cases the ratio of 5 will be acceptable.

CASE No. 812

(*Interpretation of Par. P-299*)

Inquiry: What is the limiting boiler pressure for cast-iron water columns under the requirements of Pars. P-321 and P-299?

Reply: It is the opinion of the Committee that water columns made of cast iron equal to Specification S-13 may be used for maximum boiler pressures not exceeding 250 lb per sq in.

Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later in the proper place in the Code.

The following proposed revisions have been approved for publication as proposed addenda to the Code. They are published below with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticism and approval from any one interested therein. It is to be noted that a proposed revision of the Code should not be considered final until formally adopted by the Council of the Society and issued as pink-colored addenda sheets. Added words are printed in SMALL CAPITALS; words to be deleted are enclosed in brackets [ ]. Communications should be addressed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

PAR. P-22. Add the following as the third section:

THE MAXIMUM ALLOWABLE WORKING PRESSURE FOR COPPER TUBES OR NIPPLES (CONFORMING TO SPECIFICATION S-22) USED IN WATER-TUBE OR FIRE-TUBE BOILERS, SHALL BE DETERMINED BY THE FORMULA GIVEN IN PAR. P-26. SUCH TUBES SHALL NOT BE USED FOR PRESSURES EXCEEDING 250 LB PER SQ IN., NOR FOR TEMPERATURES EXCEEDING 406 F. VALUES OF "S" FOR COPPER TUBES ARE TO BE AS GIVEN IN TABLE P-7$^1/_2$. COPPER TUBES SHALL NOT BE USED UNDER EXTERNAL PRESSURE WHEN THE RATIO OF WALL THICKNESS DIVIDED BY THE OUTSIDE DIAMETER FALLS BELOW 0.04.

PAR. P-23. Revise first sentence to read:

In determining the thickness to be used for IRON OR STEEL pipes at different pressures and temperatures the following formulas are to be used:

Add a new section to read:

IN DETERMINING THE THICKNESS TO BE USED FOR BRASS OR COPPER PIPES AT DIFFERENT PRESSURES AND TEMPERATURES USE THE FORMULA AND "S" VALUES CALLED FOR IN PAR. P-26.

TABLE P-6. Omit references and values for Brass and Copper.

PAR. P-24. Revise the second sentence to read:

The maximum allowable working pressure for feedwater piping and/or water piping below the water line shall be taken as 80 per cent of that for steam piping of the corresponding sizes as given by the rules in Pars. P-23 AND P-26 and using the "S" values, etc.

Cushing, N. Y.

PARS. P-26 and U-20*c*. Insert the following as Pars. P-26 U-20*c*:

P-26 (U-20*c*). *Non-Ferrous Tubes and Pipes.* Maximum allowable working pressures in pounds per square inch for seamless non-ferrous tubes and pipes, conforming to specifications given in Section II of the code, are to be determined by the following formula

$$P = \frac{2St}{D}$$

where P = maximum allowable working pressure, lb per sq in.,

TABLE P-7$^1/_2$ (U-3$^1/_2$) VALUES OF FACTOR S TO BE USED IN THE FORMULA GIVEN IN PAR. P-26 (U-20*c*)

Material	Spec. no.	For temperatures not exceeding deg. F: 150	250	350	400*	450
Muntz metal-tubing / High brass tubing / and condenser tubes	S-24 S-30	5000	4000	2500	..	..
Red brass tubes	S-24	6000	5500	5000	4500	..
Copper tubes and pipes	S-22 S-23	6000	5000	4500	4000	..
Brass 70-30 Condenser tubes	S-29	6000	5000	4500	4000	..
Admiralty tubing and condenser tubes	S-24 S-31	7000	6500	6000	5500	4500

* Stresses in this column may be used with saturated steam at 250 lb per sq in. gage pressures.

t = minimum wall thickness, in.,

S = maximum allowable working stress from Table P-7$^1/_2$ (U-3$^1/_2$), lb per sq in.,

D = outside diameter of pipe, in.

The formula is subject to the following restrictions:

(*a*) Applicable only to diameters $^1/_2$ in. outside diameter to 6 in. outside diameter inclusive, and for wall thicknesses not less than No. 18 Bwg (0.049 in.).

(*b*) Additional wall thickness should be provided where corrosion, or wear due to cleaning operations, is expected.

(*c*) Where tube ends are threaded, additional wall thickness of $\frac{0.8}{\text{number of threads}}$ is to be provided.

(*d*) The requirements for rolling or otherwise setting tubes in tube plates, may require additional wall thickness.

PAR. P-321. Insert the following after the first sentence:

WATER COLUMNS MADE OF CAST IRON EQUAL TO SPECIFICATION S-13 MAY BE USED FOR MAXIMUM BOILER PRESSURES NOT EXCEEDING 250 LB PER SQ IN. WATER COLUMNS MADE OF MALLEABLE IRON EQUAL TO SPECIFICATION S-15 MAY BE USED FOR MAXIMUM BOILER PRESSURES NOT EXCEEDING 350 LB PER SQ IN. FOR HIGHER PRESSURES, STEEL CONSTRUCTION SHALL BE USED.

A Correction

Our attention has been called to an unfortunate error in the account of the life of General Atterbury, which was published in the December issue, pages 789-790. General Atterbury died on September 20, 1935, and not October 20.

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Factory Equipment

FACTORY EQUIPMENT. By Joseph W. Roe and Charles W. Lytle. International Textbook Company, Scranton, Pa., 1935. Fabrikoid, $5^1/_4 \times 8^1/_4$ in., 517 pp., 208 figs., $4.

REVIEWED BY W. J. PEETS[1]

THIS volume, intended primarily as a textbook, covers in rather tabloid form, the entire subject of machine-shop operation, methods, and equipment.

Almost every known type of standard metal-working machine is described and illustrated by up-to-date cuts. There is no attempt to exhaust any of the subjects treated, the information given being of an elementary nature well-suited to students' use.

A chapter might well have been devoted to special manufacturing equipment such as drilling, milling, and tapping machines made up of standard units, and to the use of conveyers in properly relating these machines.

Chapter 1, which discusses the building method as compared to the manufacturing method of machine-shop operation, is clearly presented, and to quite an extent ties in with chapter 13 on selecting equipment. These two chapters might well be reviewed occasionally by almost any engineer having the responsibility of shop methods and tool design.

It is increasingly difficult in these times of reduced output to satisfy the demand on one hand for low capital expenditures which may mean under-tooling and the demand on the other hand for low unit cost which may mean over-tooling.

There are practical variables which often enter the economic equation which cannot readily be put on paper but a careful analysis of the aforementioned chapters is worth-while whether or not one applies the formulas to every jig, tool, or fixture made.

There is a good chapter on designing jigs and fixtures.

This work reflects in every way the wide experience of the authors. It should be particularly valuable to the young engineer getting his first practical shop experience.

[1] Assistant Superintendent, Charge of Engineering, The Singer Manufacturing Company, Elizabethport, N. J. Mem. A.S.M.E.

Books Received in Library

ABSOLUTE THERMISCHE DATEN UND GLEICHGEWICHTSKONSTANTE. By R. Doczekal and H. Pitsch. Julius Springer, Vienna, 1935. Paper, 6 × 9 in., 69 pp., diagrams, charts, tables, 6.60 rm. The measurements of specific heats and of heats of transformation, fusion, and vaporization which are scattered throughout the literature have been collected and compared, and the most probable data established in cases of divergence. The results of the study are presented in tables and nomograms which are intended to facilitate calculation. All data are calculated to the absolute scale.

AERODYNAMIC THEORY, a general review of progress published under a grant of the Guggenheim Fund for the Promotion of Aeronautics. Vol. 4. Edited by W. F. Durand. Julius Springer, Berlin, 1935. Cloth, 7 × 9 in., 434 pp., diagrams, charts, tables, 25 rm. (18.75 rm. in U. S. A.). The fourth volume of this important series contains four monographs. The first, "Applied airfoil theory" by Prof. A. Betz discusses the material derived from experimental tests and other data which are needed by the designer to supplement pure theory. The general properties of the wing, the properties of typical profiles, airfoils or wings of finite span, and unsymmetrical and unsteady forms of motion are considered. In the second monograph, "Airplane body drag and influence on the lifting system," by Prof. C. Wieselsberger, the problems presented by the nonlifting elements of the airplane are examined. Monograph three, "Airplane propellers," is by H. Glauert. The final monograph, "Influence of the propeller on other parts of the airplane structure," is by C. Koenig.

A.S.T.M. STANDARDS ON PETROLEUM PRODUCTS AND LUBRICANTS. Prepared by Committee D-2 on Petroleum Products and Lubricants. Methods of testing, specifications, definitions, charts and tables. American Society for Testing Materials, Philadelphia. Sept., 1935. Paper, 6 × 9 in., 358 pp., illus., diagrams, charts, tables, $1.75 (to members $1.). The 1935 report of the Committee on Petroleum Products and Lubricants, together with the standard and tentative methods of testing these materials and the specifications for them, are conveniently grouped in this pamphlet.

DENYS PAPIN, Inventeur et Philosophe Cosmopolite, 1647–17... (Galerie d'Histoire Scientifique). By C. Cabanes, preface by M. d'Ocagne. Société Francaise d'Éditions Littéraires et Techniques, Paris, 1935. Paper, 5 × 7 in., 286 pp., diagrams, 15 frs. In this life of the famous Frenchman special attention is paid to his pioneer experiments with steam and his contributions to the development of the steam engine. From a careful study of published and unpublished sources, the author has traced the life of the unhappy inventor, and presented an adequate picture of him.

EINFÜHRUNG IN DIE TECHNISCHE STRÖMUNGSLEHRE. Vol. 1. Theoretische Grundlagen. By B. Eck. Julius Springer, Berlin, 1935. Cloth or paper, 6 × 9 in., 134 pp., illus., diagrams, charts, tables, cloth 7.80 rm., paper 6.60 rm. (25 per cent reduction in U.S.A.) Dr. Eck gives in this volume a concise, yet comprehensive exposition of the theoretical principles of hydrodynamics and aerodynamics, for students of physics and engineering. The work is illustrated by many graphs and photographs.

FIRST COURSE IN DIFFERENTIAL EQUATIONS. By N. Miller. Oxford University Press, Oxford, Eng., and New York, 1935. Cloth, 6 × 9 in., 148 pp., diagrams, tables, $2.50. This course is intended for students who have taken a first course in calculus and have also some familiarity with the processes of algebra and analytical geometry. It aims to give a clear and concise account of the most useful methods for solving differential equations, and to provide material for practice in them.

FUEL, Solid, Liquid and Gaseous. By J. S. S. Brame and J. G. King. Fourth edition. Edward Arnold, London; Longmans, Green and Co., New York, 1935. Cloth, 6 × 9 in., 422 pp., illus., diagrams, charts, tables, $8.50. This treatise aims to give the technical man, who is not a fuel specialist, a good general knowledge of the important fuels, especially in their relation to power production. The new edition has been thoroughly revised to include the results of the research work and technical developments of the last ten years.

GEORG VON REICHENBACH, das Leben eines Deutschen Erfinders. By E. Kohler. Verlag von Knorr & Hirth, Munich, 1933. Paper, 6 × 8 in., 140 pp., illus., 3.70 rm. This readable biography of the famous German inventor and machine builder gives an agreeable account of his life, especially in his relations with family and friends, and the economic life of the day. A number of portraits add interest.

HANDBOOK OF CHEMISTRY AND PHYSICS. Edited by C. D. Hodgman. Twentieth edition. Chemical Rubber Publishing Co., Cleveland, Ohio, 1935. Leather, 4 × 7 in., 1951 pp., tables, $6. This handbook is an exceedingly useful ready-reference compendium of numerical and other data which are frequently wanted by chemists and physicists. This new edition is 18 pages larger than the preceding one, and over three hundred pages have been reset in the course of revision. Special changes include the rearrangement and enlargement of the table of physical constants of organic compounds, the addition of a formula index of organic compounds, and of the standard rules for pronouncing chemical names and naming organic compounds, and the revision of the sections on X-ray spectra and on photometry.

WHAT'S GOING ON

Including News of A.S.M.E. Affairs

This Month's Authors

READERS of MECHANICAL ENGINEERING need no introduction to RALPH E. FLANDERS, president, the Jones and Lamson Machine Company, Springfield, Vt., and junior past-president of The American Society of Mechanical Engineers, for his writings on engineering and economic subjects have appeared frequently in these pages. The penetrating and thoughtful contribution, which is this month's leading article, served the dual purpose, at the 1935 Annual Meeting of the A.S.M.E., of presidential address and Henry R. Towne lecture.

The 1935 Thurston lecture on the relation between science and engineering, presented on Honors Night at the 1935 Annual Meeting of the A.S.M.E., was delivered by CHARLES HENRY PURCELL, and described the extraordinary San Francisco-Oakland Bay Bridge, a project for which he has acted as chief engineer. A graduate of the University of Nebraska, Mr. Purcell's work in bridge and highway engineering has been carried on principally on the Pacific Coast. Following many years of practice in the state of Oregon, Mr. Purcell was appointed, in 1928, state highway engineer for the California Division of Highways. In October, 1929, the Hoover-Young San Francisco-Oakland Bay Bridge Commission was appointed and Mr. Purcell became its secretary. This Commission adopted the bridge plan under his direction in January, 1931, and he became chief engineer of the project. He is an associate member of the American Society of Civil Engineers.

R. SHELLENBERGER, who writes on "Furnace Bottoms for Tapping Ash in the Molten State," received his early education in North Dakota and completed his college work at the Universities of North Dakota and Cornell. Since 1920 he has been associated with the Bailey Meter Co., Fuller Lehigh Co., and Babcock & Wilcox Co., as a service engineer.

As general manager of the National Machine Tool Builders Association, HERMAN LIND writes with knowledge and authority in his paper on machine tools and the economic situation.

C. W. HEDBERG's connection with electrical precipitation dates back to 1916 when he first joined the Research Corporation, and this connection has continued except for a three-year period spent in the research department of the New Jersey Zinc Company. He is a graduate of Worcester Polytechnic Institute, a member of the American Institute of Chemical Engineers, and author of several papers on the application of electrical precipitation.

This month's review of economic literature "The Social-Credit Concept," from the Department of Economics and Social Science of the Massachusetts Institute of Technology, under the sponsorship of the A.S.M.E. Management Division, is by E. R. LIVERNASH, a graduate of the University of Colorado in 1932, who received a master of arts degree in economics at Tufts College in 1934. At present he is an assistant in economics at M.I.T. and is studying for a doctor's degree at Harvard.

U.E.T. Annual Report

BECAUSE of a change in its fiscal year, which now ends on September 30, the 1935 annual report of United Engineering Trustees, Inc., which is charged with the funds and operation of joint properties of the four Founder Societies, the Engineering Societies building, the Engineering Societies Library, and the Engineering Foundation, covers the first nine months of the calendar year, 1935.

A summary of the 1935 annual report, including a brief financial statement, follows:

The United Engineering Trustees, Inc., has three departments, The Engineering Foundation, the Engineering Societies Library, and the Administrative.

Under By-Laws revised in 1934, operations have been greatly simplified and clarified. The newly created Real Estate Committee has functioned efficiently in matters outside the technical operation of the Engineering Societies Building. It has cooperated in many ways with the Finance Committee, thereby distributing the heavy responsibilities placed upon a few men already overloaded by their professional interests. Distinct progress has been made toward the initiation of another permanent committee for the purpose of raising funds by gift, deed, bequest, or other method, "for the furtherance of research in science and engineering or for the advancement in any other manner of the profession of engineering and the good of mankind."

The corporation continues as treasurer for the Professional Engineers' Committee on Unemployment and has recently accepted appointment as treasurer for Engineers' Council for Professional Development, thus further serving the profession and its interrelated organizations, and fulfilling the purpose of its creation by the Founder Societies.

Members of the governing bodies of the Founder Societies and officers of their joint functional organizations met on the evening of May 20 and heard progress reports of the many projects which are operated jointly by the Founder Societies. The benefit of social contact by members of these groups was felt to be an important factor in tending to knit together more firmly the entire profession, through better understanding of the work and objectives of the different groups of joint activities of the Founder Societies.

Important improvements are being made in the public-address system in the Engineering Auditorium in order that it shall represent the ultimate in service to its users. This new system, coupled with our motion-picture projectors will make possible sound and color pictures in the auditorium, and should prove attractive to Society users and patrons and bring additional engagements. Seats have been added on the main floor of the auditorium, thus increasing comfort by the more judicious use of space. Windows throughout the Engineering Societies Building have been repaired to prevent drafts and discomfort to the occupants of the offices, at the same time conserving steam and the physical property.

The several departments of United Engineering Trustees, Inc., have remained within their budgets which were made on a most conservative basis. The income from the Engineering Societies Building activities was at a minimum owing to the continued reduction on a most conservative basis.

The value of the assets of United Engineering Trustees, Inc., and its departments, as attested by its balance sheet at September 30, 1935, was \$3,417,080.32. This was divided as follows:

Real estate	\$1,987,793.92
Endowment funds and temporary investments	1,380,754.11
Cash, prepaid insurance and accounts receivable	48,532.29
Total	\$3,417,080.32

The balance sheet does not include the value of Engineering Societies Library which is appraised at \$480,800. Further details of finances are contained in the annual report, copies of which may be obtained on request.

The two departments of United Engineering Trustees, The Engineering Societies Library, and The Engineering Foundation, together with the Administrative department (including Engineering Societies Building) finished their fiscal year ended September 30, 1935, within their allotted budgets.

New York Engineers Examining Board Elects Officers

THE 149th meeting of the New York State Board of Examiners for Professional Engineers was held at Albany on November 22, 1935. This being the Annual Meeting of the Board, the following officers were elected for the ensuing year: Chairman, Erich Haus-

mann (to succeed D. B. Steinman, who served as chairman for the past two years); vice-chairman, Virgil M. Palmer, member, A.S.M.E. (to succeed Dean Hausmann); secretary, Roy G. Finch (re-elected).

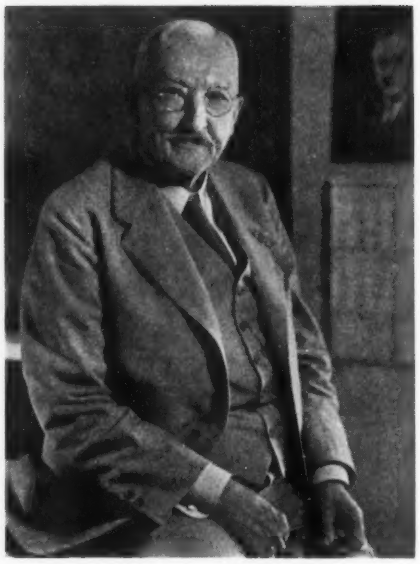
The report of the Committee on Examinations subsequent to January 1, 1937, was considered and laid on the table.

A total number of 148 applications was considered by the Board at this meeting. Of this number, 79 were rejected, 40 were scheduled for written examination, 22 were approved, and 7 were held for further consideration.

Michigan Bridge Named for M. E. Cooley

MORTIMER E. COOLEY, past-president, A.S.M.E., has experienced the unusual honor of having a bridge named for him during his lifetime. The bridge, which was dedicated on Sept. 15, 1935, is known as the Mortimer E. Cooley Bridge. It crosses the south branch of the Manistee River in the heart of the Manistee National Forest, and provides the final connecting link on highway M-55 between Cadillac and Manistee in the State of Michigan. The entire length of the bridge is 615 ft, and its longest clear span is 300 ft. It carries a 30-ft roadway with $2^1/_2$-ft sidewalks on each side, and was built at a cost of $200,000.

Past-President Cooley, who is dean emeritus of engineering at the University of Michigan, was pressed into service as head of the PWA in Michigan and has been actively engaged in this capacity. In a tribute at the dedication, Murray D. Van Wagoner, state highway commissioner who named the bridge in honor of Dean Cooley, said: "We feel that in honoring him by using his name for this bridge, the State Highway Department and all Michigan too have been honored. Wherever the principles of engineering as taught at the University of Michigan are practiced, Mortimer E. Cooley will be remembered as a kindly, under-



MORTIMER E. COOLEY, PAST-PRESIDENT, A.S.M.E.

standing, intelligent dean. Whenever in Michigan distinguished public service is appreciated, this man will be remembered for his patriotic conception of his public duty."

Watt Bicentennial January 19–21, 1936

UNDER the auspices of Lehigh University, The Franklin Institute of Pennsylvania, the North American Branch of the Newcomen Society of England, and The American Society of Mechanical Engineers, the bicentennial of the anniversary of the birth of James Watt will be observed with appropriate ceremonies at Philadelphia and Bethlehem, Pa.

According to the tentative program, the celebration will commence on Sunday, January 19, at the Franklin Institute, Philadelphia, Pa., with special displays and demonstrations of models of the steam engines of Newcomen and Watt and other appropriate exhibits. An international broadcast from the birthplace of Watt will be a feature of this portion of the program.

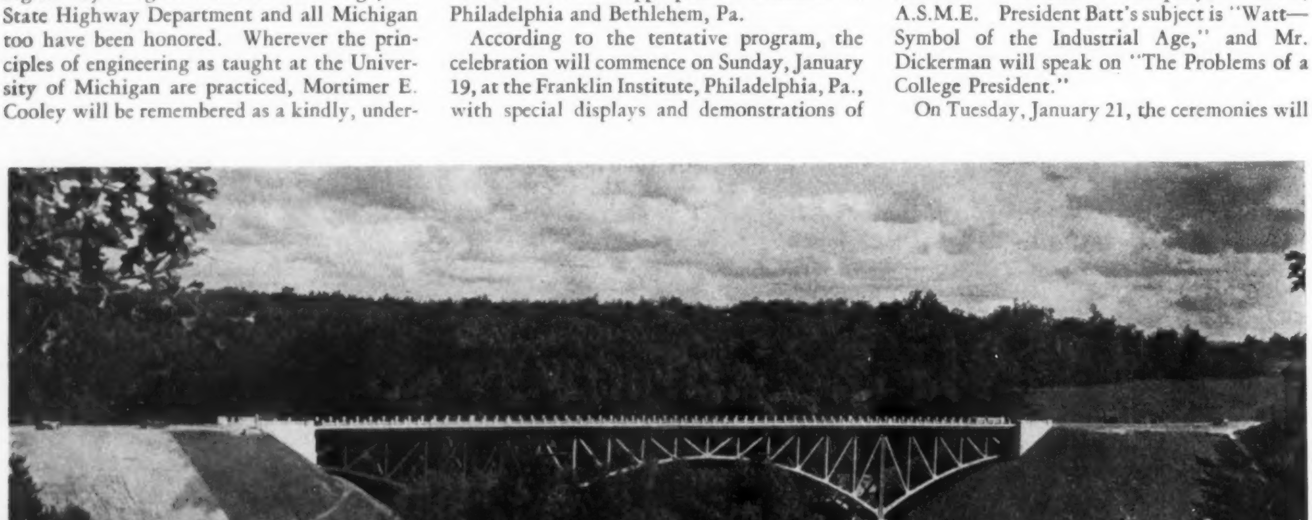
The morning session, January 20, at Lehigh University, Bethlehem, Pa., will take the form of a panel discussion on "The College Graduate in Industry," which will be held at the Packard Laboratory. Dean Robert L. Sackett, of Pennsylvania State College, member, A.S.M.E., will preside. A group of prominent industrialists will take part in the program.

Following a luncheon at the Old Sun Inn (1758), the program will resume at the Packard Laboratory with a colloquium on James Watt at which Dean Arthur M. Greene, Jr., of Princeton University, member, A.S.M.E., will preside. Three addresses will constitute the program. Geo. A. Orrok, member, A.S.M.E., will read a historical paper on James Watt. Dexter S. Kimball, past-president, A.S.M.E., will speak on developments coming out of Watt's inventions, and he will be followed by J. W. Roe, member, A.S.M.E., who will talk on Watt's business partner, Matthew Boulton.

Opportunity will also be provided for the inspection of a display of books and documents, relating to early engineering development, in the Treasure Room of the Lehigh University Library, and of working models of Newcomen and Watt engines, built in the mechanical-engineering department of the University.

An informal dinner at the Hotel Bethlehem will be followed by an evening session at the Packard Auditorium, Lehigh University, at which C. C. Williams, president of the University, will preside. Addresses will be delivered by W. L. Batt, president, A.S.M.E., and William C. Dickerman, president, the American Locomotive Company, member, A.S.M.E. President Batt's subject is "Watt—Symbol of the Industrial Age," and Mr. Dickerman will speak on "The Problems of a College President."

On Tuesday, January 21, the ceremonies will



THE MORTIMER E. COOLEY BRIDGE BETWEEN MANISTEE AND CADILLAC, MICH., DEDICATED SEPTEMBER 15, 1935

be transferred to The Franklin Institute, Philadelphia. The afternoon will be devoted to special displays and exhibits and to a meeting conducted by the North American Branch of the Newcomen Society of England at which Andrew Baxter, Jr., president, Saint Andrew's Society of the State of New York, and Sir Gerald Campbell, British Consul General, New York, will speak. Charles Penrose, vice-president for North America of the Newcomen Society of England will have for his subject "Monday, January 19, 1736." A formal dinner will be addressed by eminent persons in national engineering and scientific affairs, including Sir Ronald Lindsay, British Ambassador to the United States, and Frederick Watson, O.B.E., British Consul General, Philadelphia. J. A. Seymour, mem. A.S.M.E. will read a paper entitled "Early Experiences in Introducing the Steam Engine."

The Watt Bicentennial Committee consists of Fred V. Larkin, member, A.S.M.E., director, department of mechanical engineering, Lehigh University; Henry Butler Allen, director, The Franklin Institute; C. E. Davies, secretary, The American Society of Mechanical Engineers; and Charles Penrose, member, A.S.M.E., vice-president for North America, the Newcomen Society of England.

Metropolitan Engineers to Discuss Industrial Design

METROPOLITAN A.S.M.E. members will have an opportunity to learn how industrial designers apply their methods to strictly mechanical products on February 18, in a meeting to be held at the Engineering Societies Building at 7:30 p.m. The meeting will be devoted to a practical discussion of how color and styling improve appearance, increases performance, and reduce costs in such typical engineering products as locomotives, automobiles, household appliances, and machine tools.

For this meeting, arranged by E. F. Wright, chairman of the Junior Group Program Committee, three speakers have been secured. R. W. Carson, assistant editor of *Product Engineering* will act as chairman of the meeting, and will show in a series of typical examples how styling influenced the sales success in a number of 1935 designs. Following this series of "case histories," Howard Ketcham, consulting color engineer for E. I. du Pont de Nemours & Company, will discuss the fundamentals that a mechanical engineer needs to understand in applying color. Mr. Ketcham will show how color influences machine performance, and how designs are adapted to existing production facilities.

Practical fundamentals in industrial styling will be discussed by a third speaker, a designer with an outstanding record of accomplishments in the industrial field. Details of the procedure followed in designing a pleasing form for a series of actual designs will be given.

Since each of the three speakers is actively engaged in the mechanical-design field, members are offered an opportunity to obtain a better working knowledge of the value of form and color in mechanical engineering.

Engineers Seek Yardstick for Boys Most Likely to Succeed

IF A BOY is proficient in mathematics in high or preparatory school is he likely to make a success of an engineering course in college? Suppose he is a good speller, or has a good vocabulary, or can write a good letter or report, do those accomplishments have any bearing on the question of whether or not he should take up engineering? These are some of the things that the Committee on Student Selection and Guidance, of the Engineers' Council for Professional Development, is working out.

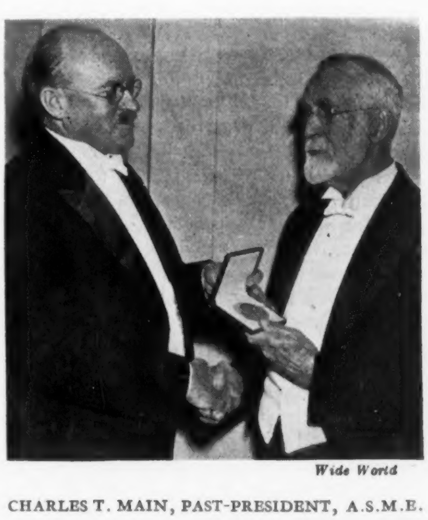
Preliminary results indicate that the answer to the first question is "yes," which is not entirely surprising. A year ago eight well-known engineering schools, at the Committee's request, gave to their incoming freshmen the cooperative test in mathematics as developed by the American Council on Education. At the end of the year the rating of each student in this test was compared with his general scholastic average for the year, and a so-called correlation coefficient determined. If this coefficient were as high as 1 it would mean that the test was a perfect indication of what the student would accomplish during the year; if the coefficient were 0 it would mean that the test had no bearing whatever on what he would do in his first year at an engineering college. The general average for 1767 students turned out to be 0.55, indicating that the mathematics test was an excellent indication of freshman accomplishments. Other tests have shown that the correlation between the first year and the other three years of a four-year course is high. If a freshman fails in but one subject he has a good chance to graduate in the regulation four years, but if he has more than one failure his chance is slim without summer school, tutoring, or correspondence courses.

Entering freshmen at the same eight engineering colleges were also given a special test in English, which was in three parts covering spelling, vocabulary, and usage. The resulting correlation between the English test score and the first-year average for all subjects in the engineering curriculum was about 0.40, or lower than for the mathematics test, but still indicative that a student proficient in the various branches of English is adaptable to engineering work. A less comprehensive study at one engineering college alone, showed that usage ranked far above vocabulary and spelling as an indicator of engineering aptitude. That is, one may be a poor speller and still be likely to succeed as an engineering student, but ability in the *use* of English is about as necessary as to be proficient in mathematics. In other words, an engineer must be able to organize and express his thoughts in clear, concise English.

The Committee directed similar work at a larger number of engineering schools in September of this year, and the correlations begun last year will be continued throughout the entire engineering course. Other tests of engineering aptitude are also being developed. It has been found that ability in descriptive geometry is an especially good criterion of the probable success of a student in engineering curricula, and it is hoped that a test can be devised for potential engineering students that will measure the same quality of imagination that descriptive geometry does. At present, there is no thought that these tests will be used to exclude students from engineering schools, but the Committee is seeking tests that will aid in selecting better students and in assuring them that they have interests and aptitudes that are likely to assure their success in the engineering field. Dean R. L. Sackett, of the School of Engineering at the Pennsylvania State College, as Chairman of the Committee, is directing the work.

Another important phase of the Committee's activities is the organization of guidance programs and procedures for the aid of preparatory-school students. Many of the local branches of the national engineering societies that are sponsoring the Engineers' Council for Professional Development have appointed committees to address high-school groups and to confer with individual students about interests, aptitudes, curricula, and fields of work. Professional engineers are especially active in this work in Milwaukee, Birmingham, Schenectady, Cleveland, Detroit, Atlanta, Kansas City, Sacramento, Baltimore, St. Louis, Providence, Philadelphia, and Washington. These engineers supplement the work of the vocational advisers at many schools. Wide distribution of a pamphlet, "Engineering—A Career, A Culture," has been a valuable aid. This may be obtained for fifteen cents from The Engineers' Council for Professional Development, 29 W. 39th St., New York.

Though only one of the four major activities of the Engineers' Council for Professional Development, student selection and guidance is fundamentally the most important for it seeks to awaken an interest in engineering by those young men—and an occasional girl as well—that are likely to achieve the highest success in the engineering field. If only the right men are encouraged to enter engineering schools a long step will have been taken toward increasing the recognition accorded to the profession.



Wide World

CHARLES T. MAIN, PAST-PRESIDENT, A.S.M.E. RECEIVES A.S.M.E. MEDAL FROM PRESIDENT FLANDERS AT 1935 ANNUAL MEETING

Associated Press

WILLIAM F. DURAND, PAST-PRESIDENT A.S.M.E., RECEIVES JOHN FRITZ MEDAL FROM ROY V. WRIGHT, PAST-PRESIDENT, A.S.M.E., WHILE PRESIDENT FLANDERS LOOKS ON

A.S.A. to Expand Work on Symbols and Abbreviations

A NEW dictionary of letter symbols and abbreviations, the "language" of engineers and scientists, will be undertaken by a committee of the American Standards Association, it has just been announced.

Rapid coinage both of new words and terms, as well as the adoption of many foreign words and phrases in the various fields of engineering and the sciences, demands a new compilation of standard usage, according to the committee.

In spite of great ramification, engineering and science are becoming more and more integrated and those working in one field find that lack of abbreviations, or confusion in their use, restricts and hampers their work.

The Committee on Symbols and Abbreviations of the A.S.A. has been reorganized and will begin at once the intricate task of coordinating existing abbreviations and symbols, and rewriting the present standards into a comprehensive manual of letter symbols and abbreviations.

The scope of the work reads: "Standardization of letter symbols and signs for equations and formulas, and abbreviations for use in publications."

In line with American Standards Association procedure, the committee is anxious to see that every group which has a problem in respect to abbreviations and symbols in its own field be represented on the committee. Any group which has published its own standard for symbols is urged to submit a copy for consideration by the committee.

Because of the difficulty involved in writing this universal simplified language for all phases of engineering, the committee is urging those interested to send comments on the standards which have already been approved, and suggestions for useful new symbols and abbreviations which are not now included, to Dr. J. Franklin Meyer, National Bureau of Standards, Washington, D. C., chairman of the committee.

Twelve standards for letter symbols, abbreviations, and graphical symbols have been developed by the technical committee of the American Standards Association which has been at work for many years. Recently, in order to simplify the work of the committee, it was divided into two parts, one covering the letter symbols and abbreviations, and the second covering the graphical symbols.

The committee working on letter symbols and abbreviations, which is now beginning its work, has twelve subcommittees covering the following broad subjects:

- Symbols and Signs for Mathematics
- Symbols for Physics and Mechanics
- Symbols for Structural Analysis
- Symbols for Hydraulics
- Symbols for Heat and Thermodynamics
- Symbols for Photometry and Illumination
- Symbols for Aeronautics
- Symbols for Electric and Magnetic Quantities
- Symbols for Radio
- Abbreviations for Scientific and Engineering Terms
- Astronomy and Surveying
- Geodesy

The committee which will prepare standards on graphical symbols will start work soon and will also request comments and suggestions on its phase of the problem.

The standards already approved by the A.S.A. in this field and which are being studied by the committee for possible revision are as follows:

- Symbols for Mechanics, Structural Engineering, and Testing Materials (Z10a-1932)
- Symbols for Hydraulics (Z10b-1929)
- Symbols for Heat and Thermodynamics (Z10c-1931)
- Symbols for Photometry and Illumination (Z10d-1930)
- Aeronautical Symbols (Z10e-1930)
- Mathematical Symbols (Z10f-1928)
- Letter Symbols for Electrical Quantities (Z10gl-1929)
- Graphical Symbols Used for Electric Power and Wiring (Z10g2-1933)
- Graphical Symbols Used in Radio (Z10g3-1933)
- Graphical Symbols Used for Electric Traction Including Railway Signaling (Z10g5-1933)
- Graphical Symbols for Telephone and Telegraph Use (Z10g6-1929)
- Abbreviations for Scientific and Engineering Terms (Z10i-1932)

Practical Absolute System of Electrical Units

THE following information was approved for publication by the International Committee of Weights and Measures at its meeting in October, 1935, at Sevres, France:

(1) In accordance with the authority and responsibility placed upon it by the General Conference of Weights and Measures in 1933, the International Committee of Weights and Measures has decided that the actual substitution of the absolute system of electrical units for the international system shall take place on January 1, 1940.

(2) In collaboration with the national physical laboratories, the committee is actively engaged in establishing the ratios between the international units and the corresponding practical absolute units.

(3) The committee directs attention to the fact that it is not at all necessary for any existing electrical standard to be altered or modified with a view to making its actual value conform with the new units. For the majority of engineering applications the old values of the international standards will be sufficiently close to the new for no change, even of a numerical nature, to be required. If for any special reason a higher precision is necessary, numerical corrections can always be applied.

(4) Table 1 on this page gives a provisional list of the ratios of the international units to the corresponding practical absolute units, taken to the fourth decimal place. Since differences affecting the fifth decimal place exist between the standards of the international units held by the various national laboratories and also because all the laboratories which have undertaken determinations of the values of their standards in absolute measure have not yet obtained final results, the committee does not consider it desirable for the present to seek a higher precision. At the same time it hopes that it will be possible to extend the table of these ratios with a close approximation to

TABLE

1 Ampere International	= 0.9999	Ampere Absolute
1 Coulomb International	= 0.9999	Coulomb Absolute
1 Ohm International	= 1.0005	Ohm Absolute
1 Volt International	= 1.0004	Volt Absolute
1 Henry International	= 1.0005	Henry Absolute
1 Farad International	= 0.9995	Farad Absolute
1 Weber International	= 1.0004	Weber Absolute
1 Watt International	= 1.0003	Watt Absolute
1 Joule International	= 1.0003	Joule Absolute

the fifth decimal place well before the date fixed for the actual substitution of the practical absolute system for the international system.

A.E.C. News From Washington

ENGINEERS' relations to national development and the economic status of the engineer will be the two major topics of the annual meeting of the American Engineering Council, January 9 to 11, at the Mayflower Hotel, Washington, D. C. Under these major themes will be grouped reports of the Council's committees on public affairs and of special and standing committees.

PLANS FOR A.E.C. ANNUAL MEETING

Last year, the heads of government agencies, old and new, presented to the delegates the various ways in which the engineering profession could cooperate in the emergency conditions in the vertical fields of government relations to manufacturing (NRA), public works (PWA), and relief (FERA), and several other subsidiary subjects. This year, what may be said to be two horizontal slices of government activities will be presented both by representatives of the government and by chairmen of standing and special committees of Council. One of these slices will concern itself with the public values of the engineers' part in national development, such as public and private construction, development of water resources, mapping and surveying, rural electrification, patent legislation and so forth. The second slice will deal with such questions as the survey of engineers, the merit system, engineers' compensation in government service, and government competition with private engineering practice.

CONFERENCE OF SECRETARIES OF ENGINEERING SOCIETIES

With the approval of its executive committee and with the cooperation of the Committee on State and Local Organizations, American Engineering Council is again sponsoring a meeting of the secretaries to be held in Washington, at the Hotel Mayflower, January 9, 1936. Kenneth F. Treschow, secretary of the Engineers' Society of Western Pennsylvania, has consented to act as chairman of this meeting.

ALL-ENGINEERS DINNER

An All-Engineers Dinner, similar to that held last year will be given Friday evening, January 10, in the ball room. The speaker is to be a man of national prominence. Last year's dinner drew an attendance of 400 engineers, including many men outstanding in federal and nonfederal work.

REPORT OF SCIENCE ADVISORY BOARD

The second report of the Science Advisory Board, established by Executive Order of President Roosevelt in July, 1933, under the National Research Council created by Congress at the request of President Wilson in 1918, has just been published. Like the National Resources Committee, it addresses itself to certain problems of national development in which the engineer and scientist have a part. The report of the National Resources Committee relates to the broader problems of the planned technical, social, and economic development of national resources. Like the National Resources Committee, the Science Advisory Board has no authority for action. It may only recommend. Both reports attempt to give broad direction to national policies—the one emphasizing the values of a planned approach to national development, the second concerning itself with the relating of government to effective research and what may be called the "tools" of planning.

The general report of the Science Advisory Board, covers such subjects as the national dependence on science, the need for a science advisory service to government, and the future development of a science advisory service. It recommends, first, that a body be set up under the National Academy of Sciences, to succeed the present reporting board, and second, that the responsible government officers and this new board continue to seek the solution of the problems which have been reported upon.

The second part of the report deals with the reorganization and reconsideration of certain of the scientific branches of the government, including the Weather Bureau, the Bureau of Chemistry and Soils, the surveying and mapping services of the federal government, the relation of patents to new industries, and a dozen other reports of inquiries into the purposes and the efficiency of present government undertakings.

FEDERAL BOARD OF SURVEYS AND MAPS PROPOSED

Once again the necessity, as well as the desirability of a basic mapping program is projected in this report. The scientists and engineers who made this latest recommendation have done so at the request of the Bureau of the Budget. Under the chairmanship of Douglas Johnson, professor of physiography, Columbia University, a committee of seven geographers, geologists, and engineers has presented the results of six months of intensive study of 28 federal agencies engaged in surveying and mapping and upon recommendations of the "Federal Board of Surveys and Maps." The report, after emphasizing the many values in such a program already well known to members of the American Engineering Council, recommends that an agency known as the "United States Coast and Interior Survey" be set up either as (1) an independent establishment reporting to the President, (2) as a unit of the Department of the Interior, (3) as a unit of the Department of Commerce. The present director of the Coast and Geodetic Survey of the Department of Commerce is proposed as the head. The new agency would comprise the following: (1) The Coast and Geodetic Survey, (2) the Topographic Branch and the Division of Engraving and Printing of the Geological Survey, (3) the International (Canada) Boundary Survey, and (4) the Lake Survey. The Committee recognizes the individuality and purposefulness of many subsidiary mapping services.

The plan, as proposed in general, has the support of all the agencies concerned. It was recommended that the consolidation proposed be brought about by Executive Order but it is understood that the President no longer has this power, so that action rests on Congressional consideration.

Thus one more nonpartisan and able effort to affect a much desired result calls for a further follow-through plan.

In November the Federal Board of Surveys and Maps requested the American Engineering Council to undertake to coordinate the opinion of map users on the need for the basic mapping program. A proposal for action will be presented at the Annual Meeting of the Council.

EXPECTED SHIFT TO PRIVATE EMPLOYMENT

Early arrivals to Congress seem agreed that there must be less spending, better planning of what is spent and that there must be a shift from government to private employment. Relatively small employment gains have been made outside of government. Millions are still dependent upon government. It is very difficult to get true figures. Industry, it is estimated, has absorbed about a million, and hundreds of thousands have found work in other phases of business. The Bureau of Public Roads reports five million man-months employment in the Federal Highway Program for the fiscal year ending June 30, 1935, financed from 1934 and 1935 emergency funds. They state that farm-to-market roads, grade-crossing elimination, and expanded highway construction are progressing at a rate which indicates they may exceed last year's expenditures and also employment.

PROBABLE CUTS IN REGULAR AND INCREASES IN EXTRAORDINARY FEDERAL BUDGETS

While there is a general belief that the so-called operating budget for normal government departments will be cut by 500 millions, it is equally evident that some sort of a clean-up and catch-all appropriation estimated at from one and a half to three billion is the President's plans for federal construction, C.C.C. camps, state relief projects, and a miscellaneous group of federal projects. There is little doubt but what such appropriations will be earmarked by Congress and not be blanket appropriations.

Petroleum Exposition, Tulsa, Okla., May 16–23

ANNOUNCEMENT has been received concerning the International Petroleum Exposition, to be held at Tulsa, Okla., May 16–23, 1936. Further announcement may be looked for.

L. S. Morse Heads A.S.R.E.

L. S. MORSE, member, A.S.M.E., executive engineer of the York Ice Machinery Corporation, York, Pa., has been elected president of the American Society of Refrigerating Engineers.

Mr. Morse received his technical education at the Massachusetts Institute of Technology

and has been associated with the York organization continuously for the past 40 years as chief draftsman, chief engineer, and executive engineer. He is well-known in the refrigeration and air-conditioning industry, and has served on technical committees of the Refrigerating Machinery Association, the American Standards Association, the National Electrical Manufacturers Association, and the Air-Conditioner Manufacturers Association.

Coming Meetings of A.S.M.E. Local Sections

Chicago: January 16. Auditorium of the Engineering Building. Subject: Materials Handling, by Nixon Elmer, Chairman of the Materials Handling Group of the A.S.M.E.

Columbus: January 17. Battelle Institute. Subject: The Glass Industry, by C. D. Smith, Superintendent, Hocking Glass Company, Lancaster, Ohio.

Metropolitan: January 9. 8:00 p.m., Textile Division. A. H. Kennedy will lead a round-table discussion of paint problems in general.

January 14. 7:30 p.m. Photographic Division. J. W. McFarlane, Eastman Kodak Co., Rochester, N. Y., will deliver a talk entitled "The New Colored Amateur Movies."

January 21. 7:30 p.m. Joint meeting of the Power Division and the American Welding Society. Mr. E. B. Ricketts will deliver an address on "The Code on High Pressure Piping."

January 22. 7:30 p.m. Management Division. Dr. Jean F. Carroll, President of General Marketing Counsellors Inc., will speak on "An Engineering Approach to Marketing."

January 22. 7:30 p.m. A representative of the Corning Glass Company will describe methods used in the manufacture of the 200-in. reflector.

January 28. 8:00 p.m. John E. Black of the Monroe Calculating Machine Company will speak. His topic is "Time Study in Management."

January 29. 7:00 p.m. A round-table discussion on power-plant problems.

Metropolitan Junior-Member Meetings: January 7. 7:30 p.m. A business meeting. The work of the E.C.P.D. and the A.E.C. for the Junior Members will be reviewed at this meeting. Junior advisers to standing committees will be introduced and there will be brief reports from Junior Committees and an announcement by the Planned Economy Study Group.

January 10. 7:30 p.m. National Defense Division. Major Robert E. Adams, retired officer of the marine corps and author of "War and Wages" will deliver a talk analyzing the motive for military and naval preparedness.

January 16, 21, and 30. 7:30 p.m. Planned Economy Study Group meeting.

January 24. 7:30 p.m. National Defense Division. Crosby Field, chief engineer for the Brillo Manufacturing Company will speak.

New Orleans: January 24–25. Headquarters of the meeting will be at the St. Charles Hotel, New Orleans, La. This will be the Annual Meeting of the Louisiana Engineering Society in which the New Orleans Section of the A.S.M.E. will participate. The technical program will be held Saturday morning, January 25, with Saturday afternoon open for recreational activities.

Plainfield: January 16. Subject: Recent Machine-Tool Developments, by A. L. DeLeeuw, consulting engineer, Plainfield, N. J.

Schenectady: January 9. Subject: Municipal Sanitation, by Morris Cohen, Schenectady City Engineer.

Youngstown: January 27. Republic Club House, Albert St., Yougstown, Ohio, at 8:00 p.m. Subject: From Ore to Seamless Pipe, by J. C. Siegle, general superintendent, Tube Division Youngstown Sheet & Tube Company. The talk will be illustrated with moving pictures, and Mr. Siegle will not only review the manufacture of seamless pipe, but will discuss its applications.

J. C. SIEGLE

February 24. Republic Club House, Albert St., Youngstown, Ohio. A speaker from the Republic Steel Corporation will provide moving pictures with sound recording showing the manufacture and application of stainless steel.

Candidates for Membership in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after January 25, 1936, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member having comments or objections should write to the secretary of the A.S.M.E. at once.

New Applications

Abbe, William Conway, New York, N. Y.
Abrams, Victor R., East Orange, N. J. (Rt)
Anastasi, Anthony J., Philadelphia, Pa.
Anderson, Harry Alfred, Naugatuck, Conn.
Bates, Arthur C., Philadelphia, Pa.
Bloom, Carl, Portland, Oregon
Britt, William H., Tonawanda, N. Y.
Dilks, James J., Jr., Philadelphia, Pa.
Gage, Warren S., Ventura, Calif.
James, G. D., Chickasha, Okla.
Johnson, Joseph A., Brooklyn, N. Y.
Keeler, J. F., Brooklyn, N. Y.
Locke, R. A., Middletown, Pa.
Marchant, John N., New York, N. Y.
Mueller, Lucien W., Decatur, Ill.
Mullen, Bernard J., Detroit, Mich.
Murray, George J., Jr., Baldwin, L. I., N. Y.
Orloff, Serge, New York, N. Y.
Oustinoff, Constantine P., New York, N. Y.
Patitz, G. N., Peekskill, N. Y.
Patterson, William L., Maryville, Tenn.
Scott, W. W., Houston, Tex. (Rt)
Searl, John, New Dorp., S. I., N. Y.
Sookasian, George H., Philadelphia, Pa.
Stoker, L. P., Burlingame, Calif.
Stroyan, George S., Milford, Pa.
Swan, S. R. B., London E. 10, England
Tucker, Stanley A., Brooklyn, N. Y.
White, Raymond E., L. I. City, N. Y. (Rt)
Wurth, Fred, Port Chester, N. Y. (Rt)
Zimmerman, R. M., Kansas City, Mo.

Change of Grading

Transfers from Junior

Cisler, Walker L., Newark, N. J.
Ehbrecht, Adolf, New York, N. Y.
Gess, Louis, Philadelphia, Pa.
Gray, David R., Spokane, Wash.
Hetzel, Theodore B., State College, Pa.
Le Blond, Richard E., Cincinnati, Ohio
Moyer, Robt. E., Jr., Allentown Pa.
Rogers, Robert E., Jr., New York, N. Y.
Seeder, Carl A., Harvey, Ill.
Shepherd, Richard B. H., Memphis, Tenn.

Necrology

THE following deaths of members have recently been reported to the Office of the Society:

Davidson, Charles J., May 26, 1935
Feybusch, Martin, October 25, 1935
Garling, Karl E., October, 1935
Harper, D. Roberts, 3d, October 19, 1935
Leonard, R. R., December 8, 1935
Rickey, Walter J., May 22, 1935
Royse, Daniel, October 28, 1935
Russel, Walter S., Aug. 17, 1935
Scott, George H., October 29, 1935
Woodwell, Julian E., October 23, 1935

A.S.M.E. Transactions for December, 1935

THE December, 1935, issue of the Transactions of the A.S.M.E., the ***Journal of Applied Mechanics***, contains the following papers:

TECHNICAL PAPERS

- Journal Bearing Performance, by R. Baudry and L. M. Tichvinsky
- Effect of Surface Rolling on the Fatigue Strength of Steel, by O. J. Horger
- A Method of Harmonic Analysis, by Frank M. Lewis
- Thermal Stresses in Plates, by John L. Maulbetsch
- The Strength and Stiffness of Cylindrical Shells Under Concentrated Loading, by R. J. Roark

RESEARCH REVIEWS

- Recent Research Work in Lubrication, by George B. Karelitz

DESIGN DATA

- Torsional Stresses in Shafts Having Grooves or Fillets, by L. S. Jacobsen

BOOK REVIEWS

- By A. L. Kimball, J. C. Hunsaker, J. R. Townsend, T. McL. Jasper, C. H. Jennings, J. Ormondroyd, M. P. O'Brien, J. M. Lessells, G. B. Karelitz, and J. A. Goff

For closing dates on discussion, see footnote on first page of each paper.